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AGARD

ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT

Sixth AGARD Annual Meeting

NORTH ATLANTIC TREATY ORGANIZATION

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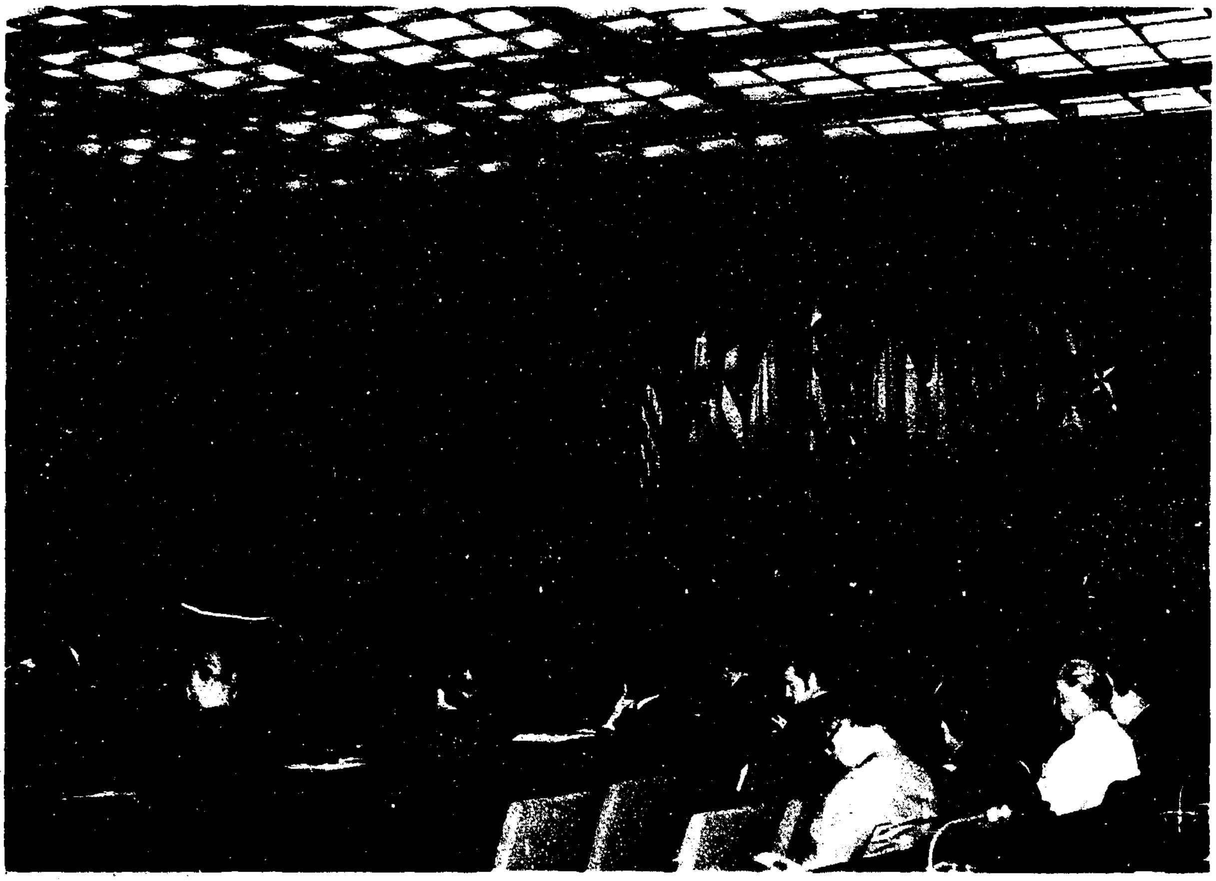
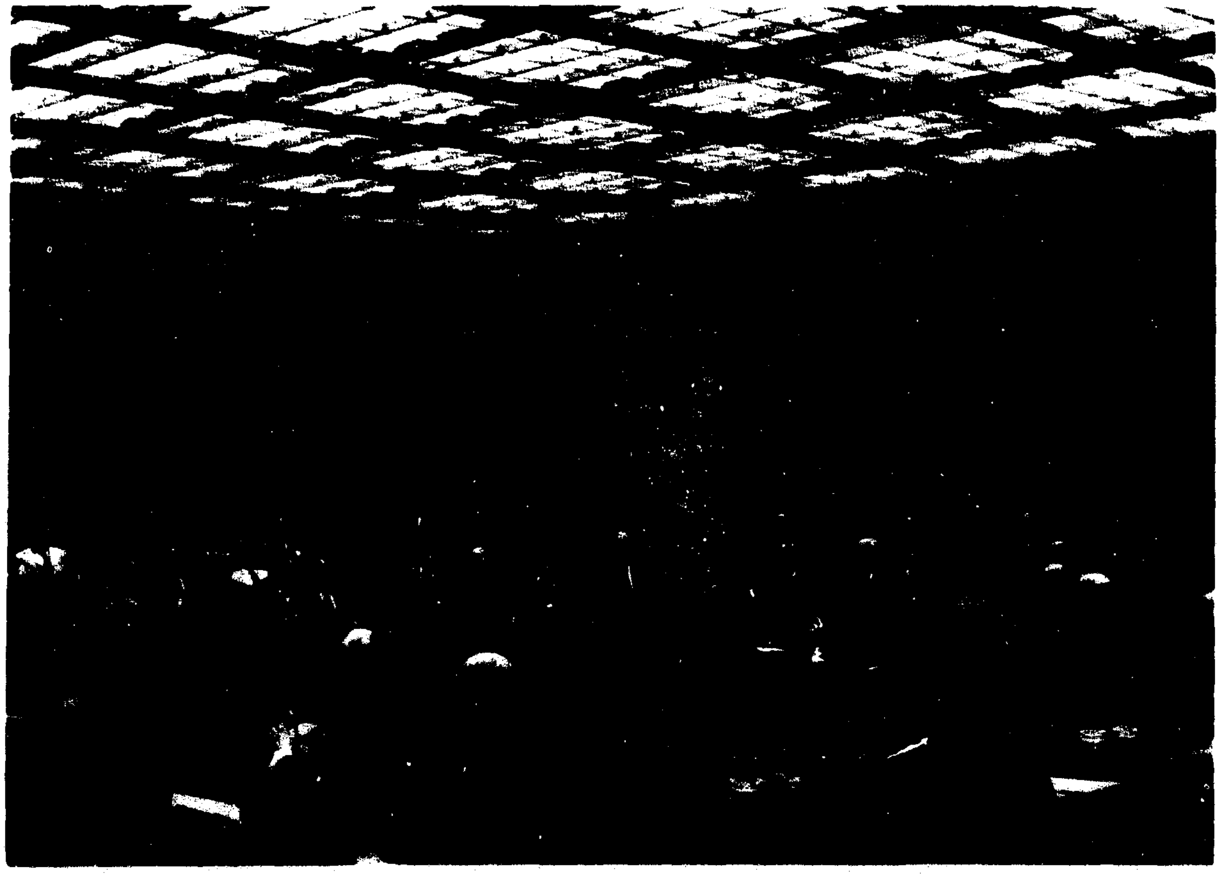
SIXTH AGARD ANNUAL MEETING

WASHINGTON, D.C., USA

6 October 1970



Welcome by the Honorable Alexis Johnson



Participants at AGARD Sixth Annual Meeting

FOREWORD

Once a year, AGARD holds an Annual Meeting in one of the NATO member Nations to develop general guide lines for future activities and to give the host nation the opportunity to present its Aerospace Research and Development program from the standpoint of the government, industry and the universities.

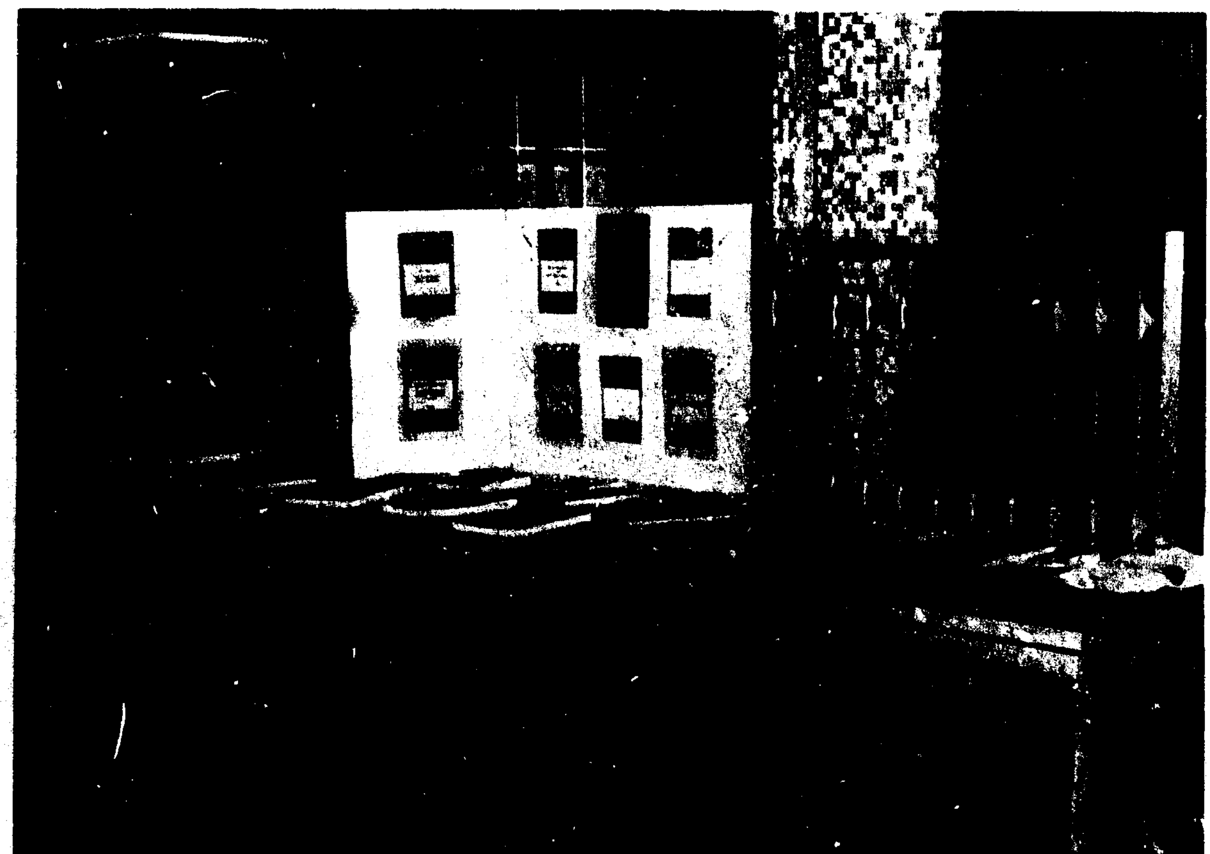
This year, the United States Air Force, supported by NASA, hosted the AGARD meeting. The President of the United States sent his best wishes for a successful meeting. The welcoming address was delivered by the Honorable U.Alexis Johnson, Under Secretary of State for Political Affairs. The Honorable Robert C.Seamans, Jr, Secretary of the United States Air Force, was the keynote speaker. The Honorable Robert Ellsworth, United States Permanent Representative to the North Atlantic Council, and Lt General Theodore R.Milton, Deputy Chairman of the NATO Military Committee, also addressed the group during the First Plenary Session.

The Second Plenary Session was devoted to presentations by the Department of Defense and NASA on the United States Research and Development Program. The Honorable Grant L.Hansen, Assistant Secretary of the Air Force for Research and Development and AGARD National Delegate for the United States, introduced the other United States National Delegates to AGARD, Dr Alexander H.Flax, President, Institute for Defense Analyses, and Mr Neil Armstrong, Deputy Associate Administrator (Aeronautics), NASA. The key speakers on the United States Research and Development Program were the Honorable John S.Foster, Jr, Director of Defense Research and Engineering, Mr Milton B.Ames, Jr, Director of Space Vehicle Research and Technology, NASA, and Lt General Otto J.Glasser, Deputy Chief of Staff for Research and Development, US Air Force. The presentations of all these speakers are reported in full in this publication.

Michael I.Yarymovych

US National Delegates to AGARD, with Chairman, Vice Chairman and Director
Dr M.Yarymovych, Mr N.Armstrong, Dr T.Benecke, Dr F.Wattendorf, Dr A.Flax, Sec. G.Hansen

Participants at AGARD Sixth Annual Meeting



Display of AGARD publications

FIRST PLENARY SESSION

Opening Remarks by AGARD Chairman, Dr Theodor Benecke

Welcoming Address by the Honorable U.Alexis Johnson,
Under Secretary of State

Address by the AGARD Chairman

Address by the Honorable Robert C.Seamans,
Secretary of the United States Air Force

Address by the Honorable Robert Ellsworth,
United States Permanent Representative to
the North Atlantic Council

Address by Lieutenant General Theodore R.Milton,
Deputy Chairman of the NATO Military Committee

THE WHITE HOUSE

WASHINGTON

September 24, 1970

Dear Chairman Benecke:

As NATO's Advisory Group for Aerospace Research and Development meets in Washington to begin its Sixth Annual meeting, I hope you will convey my warm welcome to all who participate.

Cooperation in aerospace research and development is vital to the peace and security of the NATO Alliance. As one of the leaders in this effort, AGARD is a fine example of the practical and productive pooling of talent and energy for the benefit of the entire NATO community.

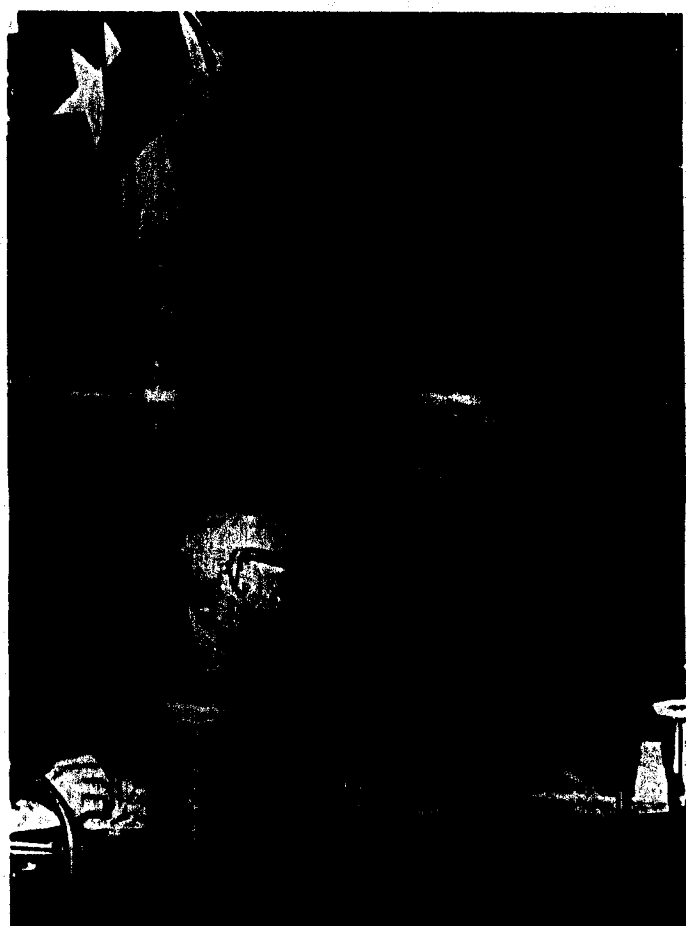
My best wishes for a pleasant and successful meeting.

Sincerely,

Richard Nixon

Dr. Phil. Theodor Benecke
Chairman
Advisory Group for Aerospace
Research and Development
APO New York 09777

OPENING REMARKS BY THE AGARD CHAIRMAN



Dr Theodor Benecke

Distinguished Guests, Ladies and Gentlemen.

On behalf of the AGARD National Delegates it gives me great pleasure to open the Sixth AGARD Annual Meeting by introducing the Under Secretary of State for Political Affairs, the Honorable U.Alexis Johnson. Ambassador Johnson has been kind enough to welcome AGARD and our guests to the United States and to this beautiful capital City of Washington. He has also been gracious enough to provide us with the outstanding services and facilities we see around us so that we may conduct our business in a most pleasant and efficient environment.

Ladies and Gentlemen – The Honorable U.Alexis Johnson.

WELCOMING ADDRESS BY THE UNDER SECRETARY OF STATE FOR POLITICAL AFFAIRS

The Honorable U.Alexis Johnson

Dr Benecke, and Delegates to this AGARD meeting, I am very honored to welcome you here to our facilities in the Department of State. I understand that it has been 13 years since you last met here in Washington and it is likely to be 13 years before you meet here again so this is a particularly rare occasion for us. We in the Department of State of course are very interested in NATO, very interested in cooperation among our allies. NATO has many manifestations, it has many organizations, and AGARD is one of the principal organizations within the NATO structure which contributes to bringing about those relations and cooperation between our scientists and technical people that mean so much to us. We in the Department of State are not entirely strangers to this whole question of technology and science. We have had it thrust upon us in recent years and even we diplomats and politicians now have to get into these fields. I recall that when I came back to the Department here in 1961, we had a science section, I suppose you might call it, consisting of two men and in the intervening 9 years we have now established science as a bureau within our department, equal to other bureaus, with a staff of 25 to 30 men. I think that it is not that we are engaged in the technical side but that what's going on in the world of science, what is going on in the world of technology, has an enormous impact upon us in the world of foreign affairs and in the world of diplomacy. Since the industrial revolution of the 18th and the 19th Centurys, the strength of countries has in large measure been dependent upon their industrial development and in the 20th Century all of us dealing with international affairs are very conscious of the fact that our industrial development depends upon the development of technology, which in turn depends upon the scientists and engineers, the genius that our people are able to bring to our society and to our industrial development. It is still true that in this age of mass organizations, of mass educational institutions, it is still true that this whole question of technology, invention, science, still goes back to the individual, and the genius of individuals. It is also still true that science does not know any boundaries. It is also still true and increasingly true that we each have much to learn from the other. Thus, we in the Department feel that AGARD and the association that you have in AGARD is contributing not only to the strength of the individual countries that are represented here, but it is contributing to the cohesion and the strength of the alliance as a whole. An alliance which has been successful in maintaining peace now for over 20 years. An alliance which was unique in that it was formed not to fight wars but to prevent wars and an alliance which I am confident will continue to be of even increasing importance in the prevention of war. It is of course our ability to fight wars if need be that enables us to prevent and deter wars. This organization is contributing to that strength, this organization is contributing to the strength of each of the countries, and it is contributing towards unity as a whole and it is in that sense that I welcome you here to Washington and to the Department of State and very much hope that your deliberations here will be fruitful as they have been in the past. As I told Dr Benecke, great thoughts will come out of this meeting, and we shall be looking forward to hearing what those are. Again, welcome here to Washington and to the Department of State.

The Chairman of AGARD, Dr T.Benecke, thanked Ambassador Johnson

Thank you, Ambassador Johnson.

Your warm and cordial words are gratefully received. I know that I speak for all of us and particularly the AGARD family who are here today – when I say that we are delighted to be here and we are truly impressed by your generous hospitality.

Your words are, of course, an inspiration for all of us. It is a tradition in AGARD to rotate our Annual Meeting among the Member Nations so that we can meet the leading national personalities and learn their views first hand. We also invite speakers from NATO so that the nations have the opportunity of meeting and listening to senior members of the Alliance. Finally, of course, and this is scheduled for the afternoon, the host nation is given the opportunity to present their national aerospace research and development program.

Thank you again, Mr Ambassador. It has been an honor to have you open our meeting and to set the stage for the day's program.

ADDRESS BY THE AGARD CHAIRMAN

Secretary Seamans, Ambassador Ellsworth, General Milton – Distinguished Guests, Ladies and Gentlemen – We are honored this morning to have as our guests Ambassador Freeman, Ambassador Gunneng, General Ryan, Dr Low, Dr McLucas, Dr Cannon and Dr Wattendorf, a very old friend of AGARD.

It gives me great pleasure to welcome all of you on behalf of the AGARD National Delegate Board to the Sixth AGARD Annual Meeting. I would also like to express our appreciation and gratitude to the Department of Defense, the National Aeronautics and Space Administration, and the AGARD National Delegates from the United States – Mr Grant Hansen, Mr Neil Armstrong and Dr Alexander Flax – for the kind invitation to hold this meeting here in Washington.

This is the second time we have met in Washington. The last time was in November 1957, almost thirteen years ago. I have a very vivid memory of that night. The first satellite, the Sputnik, had been launched on 5 October, barely two months earlier. The President of the United States, President Eisenhower, sent a message to be read at the meeting. The message said, in part, and I quote – "Your organization is engaged in a work which becomes more important with each passing year to the safeguarding of peace and security. Moreover, it serves as a model for others in practical and productive cooperation for the benefit of the whole NATO Community".

He was right, of course. AGARD has not only become more important with each passing year, but it has also become more productive. Some of the inspiring leaders at that last meeting are not with us any more and I am thinking primarily of the founder of AGARD, Dr Theodor von Kármán. However, the organization benefited from his wisdom and guidance and has grown steadily.

The number of technical panels has increased from seven to nine. The Guidance and Control Panel was established in 1965 as a result of the rapid growth and interest of guidance and control technology in government, industry and the universities. The Panel has concentrated on the interaction among the electro-mechanical, electromagnetic electronic and human operator components of guidance and control systems.

The Electromagnetic Wave Propagation Panel was established just last year – 1969 – to concentrate on satellite communications, radio meteorology and propagational prediction techniques as they relate to both civil and military applications. Earlier AGARD activity in this area was conducted in Committees.

By 1957 AGARD had organized three Lecture Series and had just begun to realize the potential value of this technique for bringing aerospace research and development to the young scientists and engineers. The Forty Third Lecture Series took place in April of this year in Brussels. Co-sponsored by the von Kármán Institute, it was concerned with an "Assessment of Lift Augmentation Devices" and was highly successful.

When the AGARD Long Term Scientific Studies were completed for the NATO Standing Group in 1963, it became necessary for AGARD to establish a permanent liaison with the NATO military authorities and other NATO bodies involved in aerospace research and development. An AGARD Steering Committee was formed consisting of AGARD National Delegates and senior members of the NATO military and civilian authorities. This Committee supported by a permanent R & D Activities Officer on the Headquarters Staff has successfully provided the necessary liaison. Twelve major reports and studies have been conducted for the NATO military authorities under this AGARD program since its formation.

At the time of our last meeting here in Washington, we were five years old and had produced 126 reports, studies and proceedings for the NATO military authorities and the scientific and technical community of the member nations.

Next year the AGARD Consolidated Index will be printed and distributed. It will list all the AGARD publications printed since the beginning of AGARD in 1952 through December of this year. The Index will provide an impressive array of over 1,000 documents including over 600 Reports and Advisory Reports, about 200 AGARDographs and close to 100 Conference Proceedings which have been and will be available in hard copy or microfiche in Europe, Canada and the United States. All of these documents are available from the Defense Documentation Center and the Clearing House for Scientific and Technical Information.

The total panel membership has increased from 134 to 325 in the last thirteen years. If we count the Consultant Program and the R & D Activities Program, the number of scientists and engineers the nations provide annually to address current problems and issues within the Alliance exceeds 600. Today the United States has fifty eight panel members and six of the eighteen panel officers come from the United States.

With this short summary of what AGARD has been doing since our last visit to Washington, I would like to introduce the Secretary of the United States Air Force. Dr Seamans is an old AGARDian. He served as an AGARD National Delegate from the United States from January 1966 until July 1969. It is a great personal pleasure for me to have this opportunity to meet him again and an honor to all the AGARD National Delegates that he consented to speak to us this morning.

Ladies and Gentlemen, the Honorable Robert C.Seamans, Jr.

ADDRESS BY THE SECRETARY OF THE UNITED STATES AIR FORCE

The Honorable Robert C.Seamans

Gentlemen, on behalf of the United States it is my privilege to welcome all of you to the Sixth Annual AGARD meeting. This the first meeting of the National Delegate Board to be held in the United States since we were able to host the Seventh General Assembly in 1957. That meeting was chaired by Dr von Kármán, whose twelve years of dedicated leadership brought many prominent civil and military personalities to AGARD gatherings – no matter where they were held. Dr von Kármán always gave generously of his time to planning, organizing, and participating on technical panels, and visiting nearly every country frequently, in furtherance of AGARD purposes. Dr von Kármán's achievements and contributions to AGARD were monumental, and I know that he is still greatly missed.

It was not until 1966, following the untimely death of Dr Hugh Dryden – a man who collaborated so effectively with Dr von Kármán, – that I became directly involved with the activities of AGARD. As national delegate from the United States, I was able to benefit from the fine professional association within AGARD, and I warmly regard the friendships that have been formed.

I recall many of you who were in attendance at the Fourth Annual Meeting in Cambridge, England, in 1968. At that time I participated in a panel on technical institutes for education and research and, in the course of our discussions, I expressed the view that neither education nor education combined with research can be conducted in a vacuum. I believed then, as I do now, that the activities of institutions such as universities, government and industry must be closely coupled together. This coupling is very difficult to accomplish and while not new to any nation, still remains a matter that requires experimentation.

This morning I would like, first, to illustrate this problem of cooperation at the national level by describing our R & D planning and decision processes here in the United States, then I will trace AGARD's efforts to date regarding national and joint cooperation, and finally offer some thoughts which AGARD might consider in shaping future programs.

Turning to our US R & D effort, any description cannot be exact, since the process is dynamic, requiring great flexibility and informal interaction. There are many essential participants in this R & D process. These include, as you know, universities, research laboratories, development laboratories, program offices, and engineering support organizations, in both industry and government. In addition, there are the Offices of Management and Budget and the Office of Science and Technology reporting to the President. Finally, there is the Congress including its relevant committees.

In the partnership that has developed since World War II, the participants have specialized to a degree. The universities have developed outstanding research capabilities in the sciences and engineering. Laboratories in government, industry, and the "not-for-profit" Federal Contract Research Centers have developed top quality groups in research and in engineering applications. Program offices have been developed in industry and government to manage system development. Part of their responsibility is to insure that the technical expertise of the country is brought to bear on new weapon systems.

Governmental agencies, such as the Department of Defense, NASA, AEC, and National Science Foundation have missions assigned to them by law. These agencies prepare and advocate programs to higher decision makers in the

executive branch and to the Congress. For example, Department of Defense proposed the B-1 bomber to replace the aging B-52's in order to help maintain a stable deterrent. The President and his Office of Management and Budget decided that the new bomber, in competition with all other things the Administration would like to do, had high enough priority to warrant development phase funding. As a next step, it will be up to the Congress to consider and act upon the proposal of the President through its investigation procedure, and the authorization and appropriation of funds.

Thus, the agency concerned, the President, and Congress address the question of "what must be done for our society and how do we propose to do it?" Once this assessment is made, an appropriate combination of the universities, the research and development laboratories, and industry provide the decision makers with alternative courses of action, which should have the highest probability of technical success. Each participant is needed, for both the user, who has no way of satisfying his need, and the producer who can find no one to buy his product, is helpless alone.

The R & D process and organization which I have described is fundamentally dependent upon national budgetary appropriations. Our Air Force R & D efforts, which are a part of this process, must operate within the resource constraints determined by the President and by the Congress. These constraints are understood by the Department of Defense which recognizes the many serious domestic needs which face our country. There is a critical need to improve the quality of our health, housing, education, and crime prevention. And there is much to be done in the area of environmental control.

In the Air Force we have found that many of our military programs produce results which have direct application to the satisfaction of domestic needs. In each case the project was tied to our Air Force mission. I have selected a few examples of such efforts.

In the field of education we deal with many levels and kinds of programs. One innovation, that has promise for wide use in and out of the Air Force, was a programmed learning course developed initially for one of our electronic courses. Basically, it achieves the long-pursued goal of allowing fast learners to move ahead at their own pace. Our experience has been that 12% of a class finished the course in about half the usual time. Another 17% or so complete the work in approximately three-quarters of the usual length, and 7 or 8% require extra time and attention. As a result, we better meet the needs of the individual and the Air Force.

Another important area of national concern is housing. At one base we are planning 200 housing units which will be constructed in various combinations of standard modules produced by a test factory at a rate of about one per day. The ultimate production cost is expected to be 15 to 20% lower than conventional construction. Everything we learn in the housing and education areas we are making available to the civilian community and to other government agencies.

Pollution control is probably receiving more publicity than any other single domestic need. For this fiscal year we have budgeted $18 million for Air Force facilities to reduce air and water pollution. We expect this to more than double in FY 72 as standards, plans, and processes are approved. These figures do not include our sizeable efforts to control exhaust from automobiles and trucks, and to minimize pollution products from jet engines. We have also been concerned with the reduction of aircraft noise. (And incidentally I noted that AGARD recently organized a symposium on sonic boom and engine noise.) Many other examples, present and past, could be cited concerning domestic spin-off from US military research programs.

This concern about domestic problems is in consonance with the shift in our national priorities. For the first time in twenty years the national budget provides more money for human resources programs than for military purposes, and I think that this is good. At the same time, we must, as a primary consideration, continue to maintain sufficient military strength to deter an enemy attack. This deterrence must remain effective if the domestic progress, which we all support, is to be possible. On the military's part and in order to satisfy the competing demands, we must realize more security per dollar spent. Improved management, which is desirable under any circumstances, thus becomes essential.

In the area of research and development, we in the Air Force have taken a number of steps toward alleviating the cost-growth problem and improving contract management. Greater emphasis is being placed upon decentralization, where a capable man is selected to run a program – and then given the authority and responsibility for carrying it out.

Also, we are attempting to carefully direct our R & D efforts, so that maximum benefit is gained from the growth potential of present systems. To accomplish this goal we must facilitate the process of technology transfer. Extensive industrial experience supports the organizational concept of rather close coupling of mission-oriented research, both basic and applied, with those development activities having near-term payoffs. At the same time, however, we cannot underrate the potential long-term benefits of broader, more basic research. Whether such research is done directly by the Air Force, by other US agencies, for example, the National Science Foundation, or in collaboration with other countries, we must continuously replenish our "capital stock" of new scientific knowledge. Not to do so would seriously damage both our military and economic positions.

This R & D approach, and the management improvements I have outlined, rest upon the research community being kept in close contact with the development community. In achieving this objective, we in this country are fundamentally dependent upon cooperation of private industry, and we must continue to work with universities in important matters of mutual interest. I am convinced that in doing so we can maintain sensitivity for such traditions as free-and-open discussion and the academic freedom of the investigator. We will solve difficulties, such as the security classification of research in good faith as they arise. As I observed at the outset, this coupling of activities – by government, industry and the universities – is a matter requiring experimentation, and its achievement is a continuing challenge.

I would like to now examine the relationship and application of our national efforts to the objectives and goals of our North Atlantic Treaty Organization, particularly as it applies to AGARD. This, I believe, can best be accomplished by reflecting on trends in our efforts to date. This gives me an opportunity to recognize the success of AGARD and to convey my personal congratulations and appreciation to the many of you here today who have contributed so actively and generously to that success. I do feel it fitting to take special notice of the presence of the Honorary Vice Chairman of AGARD, Dr Wattendorf, who as an early advocate and founder continues to contribute to the intersts of the organization.

In the early years of NATO, AGARD's efforts in concert with other NATO groups were directed toward the establishment of activities and programs necessary to develop a base for carrying out research and development throughout all the nations of the Alliance. This program was a natural adjunct to the extensive rebuilding, modernization, and economic development that also occurred. The establishment and strengthening of these development activities were necessary first steps in creating the technological base for possible future development and production of equipment necessary to carry out the objectives of the Alliance. These included activities in the fundamental research fields of aeronautics, the applied areas of instrumentation, electronics, meteorology, and also creation of the necessary experimental tools such as wind tunnels, engine and aircraft test facilities and missile test ranges.

The nations restored and strengthened their research and development capabilities on an accelerated time scale through cooperative team effort. The United States, through its Mutual Weapons Development Program, encouraged and supported the joint undertaking of systems development. Then in the mid-1950's, proposals for joint system development emerged. AGARD, through its established channels of cooperation, naturally provided technical assistance to the various NATO working groups and agencies. Good use was made of the products of AGARD exchanges in the fields of aircraft flight testing, instrumentation techniques, propulsion and aerodynamic activities.

The current or third phase of AGARD's activities reflects the maturing of its efforts with a genuine and meaningful contribution coming from all members of the Alliance. This led to the long-term scientific studies effort with broad active participation by AGARD members and contributions from many other sources. The panels in formulating their technical programs, carefully considered topics of particular military interest and excluded those subjects adequately covered by other international scientific organizations. Specific projects of joint concern, such as environmental statistical study and acoustic fatigue, were initiated by the interested nations. The latter provided national funds under AGARD supervision, and the results were shared by all the NATO countries. NATO projects on system developments continue on a multi-national basis but not as extensively as one might hope. This is where I believe we stand today.

Considering the many political, economic, and military factors associated with complex weapon system development and production, I believe we have done reasonably well in our joint efforts. On the other hand, I believe that we can do better, and suggest that we expand our joint programs. Such a course would have obvious benefits to all the nations and has been strongly endorsed by our respective national authorities.

In our multi-national cooperative efforts in NATO, I believe we should more carefully consider the lessons learned in the field of management. Through the application of new tools such as computers and large interdisciplinary groups working closely as a team, we have developed new techniques for managing extremely large segments of our national resources. An exchange of information and new knowledge relating to this very vital process would contribute to both military and civil needs. I realize there are other groups in NATO active in this field, but I believe AGARD could also contribute to the wider understanding and application of these techniques.

As a previous member of your board, I considered the responsibility of designating representatives to participate in AGARD tasks as being of particular importance to its success. Also, I believe that a special effort to bring the younger scientists and engineers into our activities is vital to the success of our program. I think we must bear in mind the great potential of the emerging generation and the responsibility they must assume in the future. I have been impressed by the enthusiasm and innovation that is evident in the youth of our nations.

The results of AGARD have been of value to the United States and we recognize their collective contribution to the interests of the Alliance. NATO's potential for useful scientific and technical cooperation remains high and the need is still present. We are all convinced that AGARD must continue to play its active role and thereby contribute to the resolve of the member nations "to unite their efforts for collective defense and for the preservation of peace and security". I am confident that it will.

Dr Benecke thanked Dr Seamans for his speech:

Thank you, Dr Seamans.

Dr Benecke introduced Ambassador Ellsworth

I would like to now introduce the United States Permanent Representative to the North Atlantic Council, The Honorable Robert Ellsworth. Prior to his appointment as the United States Ambassador to NATO in May 1969, Mr Ellsworth served as an Assistant to the President of the United States. He was also a member of Congress from 1961 to 1967 during which period he served as a member of the Joint Senate-House Economic Committee. Ladies and Gentlemen, it gives me great pleasure to introduce Ambassador Ellsworth.

ADDRESS BY THE US PERMANENT REPRESENTATIVE TO THE NORTH ATLANTIC COUNCIL

The Honorable Robert Ellsworth

Soon after his election in June, the British Prime Minister spoke in Parliament of possible cooperation with France in the field of nuclear weapons. A few days later the US Secretary of Defense observed that such cooperation might be all right if it took place within the Nuclear Planning Group.

Today in Western Europe as in North America the pollution of air and water generates a rising tide of revulsion by populations, against governments as well as against science itself.

Meanwhile a fast-growing hunger for a wide range of Western technology in Eastern Europe (including the Soviet Union) has given a new impetus to East-West relations in Europe.

Thus, I have been spared the common agony of speakers invited to address a distinguished audience of specialists ...the agony of deciding what to say. At this time and place, I didn't have to choose my topic: it chose me. It was thrust upon me by the AGARD theme for this year, "Quality and Relevance".

Israeli Defense Minister Moshe Dayan, writing in the London "Times" a few days ago, spotlighted the harsn relevance of science and technology in today's world. He said:

"When I was young, I thought the way to prepare for war in the Middle East was to learn Arabic and the geography of the desert. Now it seems that it is more important to study Russian and electronics."

In a somewhat wider framework, Albert Wohlstetter, writing in Adelphi Paper No.46 for the Institute for Strategic Studies asked the question:

"...how will new techniques transform the interest [of nations] and ability to project strength to distant places, and so the worth of nuclear and non-nuclear commitments?"

Wohlstetter spells out some answers to that question – answers based on changes in communications, in transport, in anti-ballistic missiles, in data-handling systems, and in multiplication of armed re-entry vehicles carried in a single launch vehicle as well as improvements in offensive accuracies and reliability. He particularly stresses the importance of extraordinarily rapid changes taking place in "the basic elements" of the systems which affect both conventional and nuclear military planning: for example, computers – and particularly solid state and microelectronics.

More precisely, science and technology have emerged as key elements in East-West diplomacy – most recently in the West German-Soviet Renunciation of Force Agreement of August 12.

Thus, it is your theme – "Relevance" – which has been underscored by recent events ... and which imposes itself as the topic for any diplomat talking to you today.

It would be easy to shrug off current diplomatic activity in Europe as more of the same old thing. We are, after all, trying to reduce political problems left from a war that ended twenty-five years ago. We are negotiating across a barrier that was labeled an iron curtain by Winston Churchill speaking to college students who are now in their mid-forties. The difficulties in Europe are familiar: basic differences of view, lack of confidence, the doctrine

of limited sovereignty, and questions about the future of Berlin, and of Germany. But there have been significant changes, and the present period has a considerable novelty. One of the critical factors that have stirred the pot has been advanced technology. For the two centerpieces of current diplomatic activity in Europe today are marked by the fact that transfer of technology is one of the key questions in both.

First, the Soviet proposal for a grand Conference on European Security. A key element in the sustained Soviet diplomatic push behind this proposal is the hunger (which has not been concealed) of the Warsaw Pact for access to the science and technology of the West. Over the last few years, Warsaw Pact communiques have called repeatedly for "expansion of trade, economic, scientific and technical relations" between East and West. This appears, on the face of it, to be a prime goal of the Soviets.

The other area of current diplomatic activity which appears to have a strong new technological content was highlighted on August 12 by the signing of the German-Soviet Renunciation of Force Agreement in Moscow*. This document reiterates the theme sounded in the Warsaw Pact appeals for a Conference on European Security: i.e., a concern to expand scientific and technological "exchange" between Russia and the West. One of the basic purposes of the Moscow Agreement, noted in the Preamble, is the

> "improvement and extension of cooperation between [the two countries] including economic relations, and scientific, technical and cultural ties..."

This is not the empty rhetoric of unread preambles. To the contrary, the evidence is that it expresses a deep Soviet need, and that the treaty itself reveals something important about the present content of East-West political relations.

I do not mean to suggest that Moscow's drive for a Conference on European Security, or its strong interest in a renunciation of force agreement with the Germans, is based solely on its desire to improve its access to Western technology. Moscow s reasons are many and complex and they are rooted deeply in Russian – and European – history. Nevertheless, a profound desire for access to Western technology must be considered an important source of the new political atmosphere in Europe.

For today's Soviet diplomacy in Europe is driven by one of the most fundamental political motivations of any leadership system: the urge to remain in power. Not just the Soviet leadership personalities of the moment, but all those who are associated with the system from which those personalities have emerged, and those who have reason to believe the same system will serve them well in the future. And it is clear that a painful slowness of application of modern technology in Soviet society is regarded with alarm as a grave problem by the Soviet establishment today.

Soviet leaders have been surprisingly outspoken on this point. There has been public expression of concern about their need to close or narrow the growing technology gap between East and West. Communist Party Chief Breshnev himself acknowledged on April 14 that it is in the application of modern science and technology to the Russian economy where:

> "the center of gravity in competition between (the two great world systems) is to be found."

The now famous Sakharov letter, sent to Mr Breshnev in 1968† by the prestigious father of the Soviet H-bomb, Andrei Sakharov, had warned the leadership that:

> "A decisive factor in the comparison of economic systems is labor productivity, and here the situation is worst of all. Our productivity remains many times lower than in the developed capitalist countries, and its growth has drastically slowed. We simply live in another epoch."

The only solution, according to Sakharov, would be:

> "the widespread introduction into the economy of automation and computer technology."

There are two ways for a nation to get science and technology. If it has the wealth, the trained scientific manpower, the education system, and the time, it can develop autonomously in these areas. If not, it can acquire important technological assets pre-packaged from elsewhere. It is certainly a fact that one usually saves money by buying patent rights, and that one usually saves time by importing technology.

Thus, the strong Soviet desire to sharply increase their rate of acquisition of Western technology.

Some major difficulties for the Soviets remain, principally their inability to pay for that technology. They would be able to pay if they could balance their imports by increasing exports of raw materials, and oil and gas, but they are unable to achieve this balance. Thus, they must ask for credits – credits which would have to be

* The Agreement has not been ratified.

† No exact date is known to Western scholars and journalists.

guaranteed, or possibly even subsidized, by governments. In essence such an agreement is not trade, but aid. Decisions about extending such aid, as well as decisions about transferring advanced technology from West to East, are not simply economic or technical decisions. They involve the highest political considerations.

Political considerations also govern the fact that there are items of the most advanced technology the Soviets would be unable to obtain under any circumstances from the West, or from certain countries in the West – even if they were able to pay. Given the basic security interests of Western nations, coordination of national policies in setting and following these restrictions has proven to be possible and continues to be desirable.

The classic blunder in violation of this principle was committed 400 years ago by the Duke of Urbino. He possessed by far the most advanced artillery of the 16th Century, which he foolishly loaned to Cesare Borgia for the alleged purpose of a Borgia attack upon Naples. Instead, Borgia promptly turned the artillery upon Urbino as he had planned all along. That was the end of Urbino.

Naturally, the Soviet Union's desire to create a situation in which political decisions would be favorable to itself is understandable. This explains much of the political purpose of the Moscow Agreement of August 12, as well as the sustained diplomatic push for a grand Conference on European Security designed, in large part, to facilitate imports of technology from the West.

The process of technology transfer is under way. The German Minister of Science and Education has just spent twelve days in Moscow laying the groundwork for scientific and technological cooperation between the two countries, and a Soviet delegation will visit West Germany shortly to study details of this exchange. Last week Soviet Deputy Premier Kirillin said that agreement had been reached favoring cooperation in such fields as high-and-low-energy physics, physical chemistry, astronomy, biology, medicine, oceanography, computing techniques, and some general areas of information and education. Earlier the German Minister had suggested that some day German experts would work in Soviet space centers and that a German research satellite would be launched with the help of a Soviet rocket.

And this is not an isolated development. Joint scientific research and cooperation agreements have also been reached with Italy, Britain, Sweden, and Belgium.

Just last week, several British companies agreed in principle to help build and finance four industrial projects in Russia.

France and the Soviet Union have established a permanent joint commission to develop scientific, technical and economic cooperation between the two nations. Working groups have been set up in such key industries as engineering and metallurgy, and they are now studying proposals on the establishment of a number of industrial complexes in the USSR involved with the latest French scientific achievements and with the use of French credits and modern French equipment.

This intense hunger for technological development in Eastern Europe appears to be more than simply a leadership decision; it seems to be shared by the general public. A recent study of public opinion in ten nations, carried out by the European Coordination Center in Social Science, located in Vienna, showed that people in Poland, for example, (and even more in the Third World) are highly enthusiastic about what science can do for them. They look to the future benefits of modern technology with the zest of a nineteenth century visitor to a Victorian World's Fair.

What is interesting here is the contrast between West and East drawn by the Vienna study; and that brings me to my second point about the need for a discerning policy-oriented attitude toward the technology of our time.

The Vienna study contrasts the uncritical enthusiasm for technological development in the East with the frequent lack of enthusiasm in our own highly developed countries. In fact, the study found a crisis of confidence in technological development in the West – a feeling that the straightforward goal of "more development" was not a satisfactory goal.

The citizens of the highly-developed nations of the West who responded to the study's questions were, I believe, reacting to certain new and overwhelming impressions about the factors which make today's scientific gains a package of mixed blessings. They were displaying their feeling that automobiles mean traffic jams and air pollution, that vast truck factories mean urban industrilization and decay, that computers can be seen as bringing subservience to machines, and loss of individual identity.

There is thus a difference in the fundamental circumstances in which the East and the West find themselves. It is a difference between the hearty appetite of people who have not yet enjoyed an abundance of technology and the more critical attitude of people for whom much of the wonder of the twentieth century has lost its novelty.

It is a difference between those whose awareness of a need to develop and acquire is stronger than their perception of the possible accompanying agonies ... and those for whom the destruction of our environment crisis has become a *cause célèbre*.

Objectively, the contrast is sharp. The tasks of the two societies – development on the one hand, and control of the unintended secondary effects of development on the other hand – are different. But this does not mean that either task is inappropriate. In the different circumstances which exist in East and West, it is entirely appropriate for the leadership of each society to "do its own thing".

And it may not be politically inappropriate for the West to be willing to transfer some of its technology to the East. But we have now indicated two grounds upon which critical judgements must be exercised in considering such transfer: international political relations, and quality of life on our crowded planet. If technology is to be a source of satisfaction, we will have to re-think our forms of scientific and political endeavor.

Scientific and political endeavor come together within the North Atlantic Alliance every day. Our Alliance, which was founded to express the inescapably inter-connected security interests of the countries of Western Europe and North America, soon found that if risks and strategy were to be shared, technology must also be exchanged and shared. What *is* surprising, given the history of defense alliances, is that the techniques and habits of scientific and technological exchange should develop as precious assets in themselves – assets of the Atlantic Alliance which are available for use in non-military areas.

Your activity, of course, bridges both military and non-military utility. The work of AGARD in the area of international technological exchange is tremendous. The thirty or more major meetings this year, not counting the dozens of smaller meetings, bring together, hundreds of NATO's finest scientists whose individual and collective efforts play a large role in enabling us to maintain technological superiority over the East.

Since the formation of AGARD, technological progress of its NATO members has made giant strides forward and we are now in an era where no one country is the leader in all fields. This fact, coupled with the high costs in money and in manpower – of sophisticated projects, requires all of us to exploit technological exchange, and to minimize duplication of our efforts. Dr John Foster, our Director of Defense Research and Engineering in DOD, calls this "International Interdependency". He feels that limitation of national R & D budgets, and the desire to maintain interoperability as well as currency of our NATO weapon systems, should increase national efforts for cooperation on a quid-pro-quo basis. For example, perhaps, the US should buy vertical Take-Off and Landing Aircraft, small Air Defense Radars, or Laser Range Finders from Europe. Conversely perhaps European nations could procure a follow-on Tactical Missile System, a Hydrofoil Fast Patrol Boat, or possibly Anti-Tank Weapons from the US. At present, these are only ideas, but they should be brought to fruition. Our hope would be that these transactions could be arranged in such a way that the net change in balance of payments would be negligible. The opportunities are endless if we can only keep building and improving our technological exchange. However, one must recognize that sometimes technological exchange which appears palatable and even desirable to the scientist may raise political or diplomatic problems. Therefore, those of us who are in politics, or diplomacy, must work hand in hand with you who are members of the scientific community if we are to continue to make progress in mutual interchange of products and efforts.

Advanced technology also produces the side effects we point to when we speak of problems of the environment. It was because of NATO's political strength, as well as its proven record of success in managing technology transfer, that President Nixon in April 1969 urged the Alliance to create a Committee on the Challenges of Modern Society, to arrest the deterioration of the quality of our life in the last third of the Twentieth Century.

The problem is a massive one, because our inventiveness has been formidable. With great effectiveness, we have filled our air and water with the filthy side effects of industrial progress. Our cities offer the lungs the exhaust gas of a million internal-combustion engines. Our ears are shaken by the booms of jets and the rumbles of trucks. But we cannot move away and leave our mess behind – we've run out of Earth. Thor Heyerdahl found plastic bottles and blobs of oil on huge patches of ocean in the middle of the Atlantic. Jacques Cousteau has pointed to a five-fold increase in the lead content of the world's oceans in the past fifty years, fifty-two tides of dead fish in eighteeen months between Florida and Texas, and the death of 250,000 sea birds every year off the coasts of Britain, through pollution.

This is a crisis calling for much more than picking up empty cans from beaches or preventing factories from dumping waste into rivers. It is the entire job of organizing and interpreting interrelated facts, and then converting them into effective political action. The technology to do the job is largely available, but the political will to employ the technology must be galvanized. The political leadership of modern society must be harnessed to a refined and balanced technology, which can be used to control and arrest the unintended pollution of our environment. As Daniel P.Moynihan, the President's representative on the new NATO committee, has pointed out, there already exists

> "a considerable body of technical knowledge that, if applied with sufficient vigor and purpose, would enable industrial societies to halt and to reverse the degradation of the natural environment."

This purposeful application of knowledge must of course be international. The Rhine River is even more polluted than the Ohio, and it touches the borders of four nations. A nation can be fully sovereign and yet entirely incapable of dealing with the poisoning of the environment within its own borders.

Most of the members of the North Atlantic Treaty Organization are highly industrialized countries with advanced technologies. They are also, therefore, countries afflicted with the environmental problems which flow from the unintended consequences of technology – and at the same time they possess the scientific and technological means of coping with those problems.

Starting with NATO's unique experience of years of effectively managing the transfer of technology on an international basis ... and starting with NATO's proven ability to influence the highest political levels of member governments ... we have made a beginning in NATO's Committee on the Challenges of Modern Society, CCMS, in the effort to use the strength of NATO to bring effective action to bear on the problems of our environment.

1. In Frankfurt and Ankara: German, Turkish and American experts are carrying out a CCMS pilot project on urban air pollution.

2. In Dearborn and Brussels: experts from nine NATO nations, plus Sweden and Japan, have combined their efforts to improve auto safety. The need here is well recognized. One-third to one-half of the cars manufactured in NATO countries wind up with blood on them. It's absurd to think that our marvellous technology cannot cope with this threat to life and limb.

3. Lake Erie, which lies between the US and Canada, has already died because we are doing to our water what we are doing to our air. In Belgium, sportsmen fish among beer cans; and in Ohio a river caught fire recently and burned down two bridges. Canada is organizing a CCMS pilot project for an international assault on inland water pollution.

4. And, for the quite different problem of ocean pollution, the Belgians have taken the lead in preparing for next month a colloquium on the massive problem of oil spills.

5. Italy has taken responsibility for a CCMS study of disaster relief, including the organization of a symposium on flood mitigation.

6. And the Germans are going right to the heart of the matter, as German social scientists are probing the central question of how best to channel scientific knowledge into the political decision-making process.

All this work has been moving at a pace which is extraordinary. These projects are already pointing, not toward ringing exhortations or years of further research, but toward political action – based on research which has already been done, or on short-range research directed to preparing for action.

It is not too difficult to see that technology transfer among various groups of nations will be a key to international relations in the next few years. There will be mutual exchange between North America and Western Europe, government-subsidized transfer to the Soviet Union and Eastern Europe, and – hopefully refinement, balance, and discipline in the science and technology of all nations but most especially in our own.

Sir Harold Nicholson once listed the qualities required of a good diplomat in the 15th and 16th centuries. He had to be a man of taste and erudition, and to cultivate the society of writers, artists and scientists. This requirement was placed between injunctions to employ a good cook and to be tolerant of the folly of one's own home bureaucracy. The need for good cooks and tolerance remains great, but the relationship between scientists and diplomats has changed. The diplomat must now contrive to understand what the scientist is saying to him, and the scientist must relate his efforts more precisely to the policy pattern of international relations.

The scientist is, willy-nilly and like-it-or-not, in an exposed political position in our civilization. He is not only at the center of the arena of domestic politics and international diplomacy, but he is looked to by the actors in those fields to explain and help solve the very problems that science has created.

This new situation is beginning to make new and intensified demands upon the scientist ... demands upon him to know something about politics and diplomacy ... demands upon his ability to communicate with policy leaders ... demands upon him to accept his responsibility actively to assist that political leadership to impose the necessary controls and discipline upon science and technology.

So it is that, in international relations, the question of Eastern access to Western technology cannot be viewed simply as a question of science and technique moving naturally and inexorably all over the world without regard to territorial borders. My concern today has been with the *political* meaning with which the exchange of technology is inevitably laden. The scientist who would disregard the basic patterns of changing international relationships has probably ignored the question of the relevance of his work.

And I have also touched today on a second area where an *uncritical* pursuit of technological progress represents a danger. Our understanding of what we have done to our environment, to its essential equilibrium and its function as the source and context of life, if life is to exist on our planet ... this understanding must keep pace with development and must produce a social and scientific discipline capable of saving our environment. So it is that the scientist who fails to work toward the discipline and use of technology to improve the quality of life risks irrelevance.

Both of these problems of relevance demand a *critical* and *controlled* development, worked at by scientists who are knowing and responsible not only about international diplomacy but also about the challenges of modern society. It was concern for the relationship between science and modern international society that led President Nixon to suggest the creation within NATO of a Committee on the Challenges of Modern Society.

The same international partnership finds us here today accepting, at your gracious invitation, our common responsibility to understand each other and to act. I hope you have a most successful meeting here in Washington.

Dr Benecke thanked Ambassador Ellsworth

Thank you, Ambassador Ellsworth.

Your comments and observations on the future will leave a lasting impression with all of us. There is no question that all of us feel in the middle of a great socio-economic change which will leave its indelible mark on the next decade. It is an honor to be working with you to insure that the Alliance weathers the storm in a constructive forward-looking and viable fashion. Thank you.

I would now like to introduce our next guest speaker. As you know, AGARD is a military agency under the authority of the NATO Military Committee. We have been fortunate each year to have a member of the NATO Military Committee address our Annual Meeting. This morning the Deputy Chairman of the NATO Military Committee will speak to us. Ladies and Gentlemen, Lt General Milton.

ADDRESS BY THE DEPUTY CHAIRMAN OF THE NATO MILITARY COMMITTEE

Lieutenant General Theodore R.Milton

Dr Benecke, distinguished guests, National Delegates. The Chairman of the Military Committee, Admiral Henderson, spoke to you in Paris last Spring of the progress that had been made in NATO Headquarters on actions that the National Delegates Board had recommended. Today I would like to bring up to date that progress report and, additionally, give you a brief idea of the initial response to the questionnaire on AGARD output and benefits to NATO and I would also like to speak to you of some of the problems facing the Military Committee in the hope that knowledge of them might aid you in your work.

First, the progress report. MC 152 which is the document establishing Military Committee policy and guidance for AGARD, was approved by the Committee on 22 April 1970 and is now in force. On 4 June the Military Committee received an interesting and thorough briefing on AGARD activities. I think the briefing was helpful in reminding Military Committee representatives that they must take a more active role in AGARD affairs, especially those concerning the budget. During the course of the briefing Dr Benecke also brought forth a proposal to give technical briefings to the Military Committee on suitable subjects of interest. The first of these I hope will be given soon, and this might very well begin to close the gap that I think clearly exists now; a gap and lack of understanding by the governing body, the Military Committee, of the work that you do.

Turning now to the questionnaire. An initial glance shows that it will be helpful in making the Military Committee more knowledgeable on the program and results of AGARD activities. Questions covered a wide spectrum and the answers were for the most part thoughtful and detailed. We found that the distribution of AGARD documents was wide spread and it was especially encouraging to note that the publications were utilized by many colleges and universities, especially in areas of research and thesis preparation. One country indicated that students in their final year used the publications at least as freely as textbooks. If distribution was wide spread therefore so was usage. One country cited 15,000 requests for AGARD documents as an indication of industrial interest. Naturally publications were most popular in those countries with aviation and aerospace industries, although one country without a specialized aerospace industry found use for AGARD literature for a development project in sound wave measuring techniques; AGARD publications ended up in such diverse places as Le Centre d'Etude de la Corrosion in Belgium and the Ionosphere Laboratory of the Technical University of Denmark.

So we see there was adequate distribution of the publications. Now, how were these publications applied towards developing equipment for military or civilian use? Responses here vary considerably but, in summary, nations found a direct benefit from AGARD in such areas as flight test documentation, current status of potential developments in the V/STOL, definition of structural criteria, and advanced compressors and turbines.

One of the more interesting indirect applications was the utilization of AGARD reports in the development of laundry machinery – a real spin-off.

Nations felt that their research benefits greatly from their contributions to support AGARD. The various AGARD activities have allowed scientists and technicians to look toward each other and establish personal contacts for the purposes of discussion and research. What a small country can offer from limited resources often is much appreciated elsewhere, particularly when it fills a gap existing in the program of another country.

AGARD publications seem to have helped greatly in allowing different national experts to speak the same technical language.

Finally, the questionnaire addressed itself to a call for recommendations towards the improvement of the AGARD program. So many recommendations were offered that I will only summarize some of the more significant. Suggestions were made to review where the work methods adopted by panels may be improved and to encourage the establishment of ad hoc groups to study specific questions in limited areas. The recommendation was also made for more active representation of senior military personnel in the belief that this would contribute toward the relevance of programs. Another suggestion was that smaller groups of the Alliance be encouraged to greater participation. More definitive guidance from the Military Committee was suggested. It was felt that the 1970 revision of the AGARD Charter and the Military Committee procedures for tasking AGARD are improvements, but that many of the panels operate semi-autonomously and should be more aware of the requirements of the Military Committee.

It seemed apparent in a general reading of the questionnaire responses that the attraction of AGARD for qualified scientists and engineers is the high scientific standards of the meetings, the possibilities for informal scientific contacts with colleagues in other countries and the relative freedom of the panels to select suggestions within their domain for study which tends to lead to self-generation of valuable programs within the panels themselves.

In summary, then, the questionnaire reflects a general and impressive interest in the activities of AGARD. Your publications are read with interest and appreciation. So much then for the questionnaire except for one last conclusion. The most repeated recommendation was one asking for more definitive guidance from the Military Committee.

Now if you will allow me to take a large view of that recommendation, I will attempt a little guidance today – not precisely on behalf of the Military Committee, but as one who will presume a sense of what the Committee wants from AGARD. A little history might serve as a proper point of departure.

More than 20 years ago we could operate military aircraft with ceilings of 200 feet and visibilities of 1/4 to 1/2 mile. Two decades later these are still, for operational purposes, our minimums. Research in improved operational capabilities tends to follow the pressures of the time. I think our weather minimums reached their present levels under operational pressure. They have tended to stay there, in my view, because the pressures have relaxed. We have not had a real emergency in Europe since 1949 and research has interested itself in more exotic things.

One of the principal problems facing NATO air forces today is how to get qualitative improvements within realistic budget levels. Qualitative improvements in every area. Improvements in survivability of aircraft on the ground. Improvements in survivability of aircrews. Improvements in all-weather capabilities. In weapons delivery accuracy.

For example, our NATO aircraft inventory includes such planes as the F84's, G91's and C119 – all planes that would not give much account of themselves in a modern war. Ideally they should be replaced on a one-for-one basis, but defense budget reductions make this difficult. Short of replacement, technology can help balance the equation. Each improvement that can be made to an aircraft or to the environment of its pilot to make a technologically "better" aircraft wil help close that gap.

The strategy of flexible response means just what it says and a key element in flexible response is the ability in the early stages of the conflict to make the conventional phase of the strategy so effective that we never need go on to a bigger phase. A very key part of this lies in the ability of the allied air forces to compete against greater numbers and gain air superiority – hopefully air supremacy – in short order. There is no one magic answer to this.

To select at random one of the items I mentioned earlier – that of weapons delivery accuracy. In World War II fighter bombers could deliver conventional weapons, in clear weather at least, as accurately as present day fighter bombers can deliver the same weapons. The fighter bombers now come in at much higher air speeds but the bomb itself is essentially unchanged and the accuracy, if anything, has suffered with increased release altitudes and air speeds.

Or to select another item – that of the survivability of aircrews – the most single valuable asset in the allied air forces. Looking through the index of AGARD publications it is clear that there has been much attention paid to the protection and survivability of our aircrew resources. I would suggest that this continue to occupy your attention on a priority basis and that AGARD itself might consider creating a special Life Support Panel in order to call more attention to this especially rewarding area for research. No area, in my judgment, could be more rewarding.

I suppose this is another way of saying that if AGARD wishes to call the attention of the military to its efforts, then some projects with immediate application would be a good way to do it. Nothing appeals to the military man faced with immediate problems so much as an immediate solution. While all of us realize the essentiality of pure research, we are nevertheless fully conscious of the fact that you always have to fight with what you have and so you are constantly trying to improve in one way or another your current resources.

Now NATO has some serious problems, evident to any casual if knowledgeable observer. They are problems of obsolescence, of lack of standardization – and this one is getting worse as the United States air assistance program winds down and nations begin to re-equip themselves on the basis of national decisions – and of simple disparity in numbers between NATO and the Warsaw Pact. This last one is one that lends itself to remedy through technological superiority. One airplane that can hit a target is worth, by a factor almost exactly equal to its increased accuracy, greater numbers of airplanes that cannot. I say almost because at some point sheer numbers do begin to be an overwhelming factor. As a matter of fact, General Arnold in 1944 during World War II said something to the effect that the Allies were winning by sheer weight of numbers and mass production and that in the future technology would have to play a much bigger part. Well, this is the future. We don't have the numbers, we aren't ever likely to have them again in the sense that we had them on the allied side in World War II, so we are in fact dependent for our superiority, perhaps our very survival, on the kind of qualitative improvements that research can bring us. In my perhaps prejudiced, but nonetheless convinced, view air will be the decisive factor in any conflict in Europe, and it will be decisive very quickly. Equally, a visible and highly sophisticated air capability is perhaps the best deterrent, and deterrence after all is what NATO is about.

You have a great deal to contribute in your unique forum that is AGARD to the constant revitalization of the NATO air technology, and from time to time it might be worth remembering that a few practical applications will do more to convince the Military Committee of the essentiality of AGARD than hundreds of pounds of technical reports.

Dr Benecke thanked General Milton for his speech:

Thank you, General Milton.

I was particularly interested in your remarks concerning the questionnaire prepared by the Military Committee and sent to the member nations for comment. It is indeed gratifying to know that the services AGARD provides to the member nations are appreciated and put to such important and valuable use.

Secretary Seamans, Ambassador Ellsworth, Ladies and Gentlemen, this concludes the First Plenary Session of the Sixth AGARD Annual Meeting.

SECOND PLENARY SESSION

Opening Remarks by the Chairman of AGARD

Introductory Remarks and Recognition of the US National Delegates to AGARD by the Honorable Grant L.Hansen, United States National Delegate to AGARD

Address by the Honorable John S.Foster, Jr, Director of Defense Research and Engineering

Address by Mr Milton B.Ames, Jr, Representing the National Aeronautics and Space Administration

Address by Lieutenant General Otto J.Glasser, Deputy Chief of Staff, Research and Development United States Air Force

Annual Meeting closed by the Chairman of AGARD

OPENING REMARKS BY DR BENECKE

Dr Foster, Distinguished Guests, Ladies and Gentlemen.

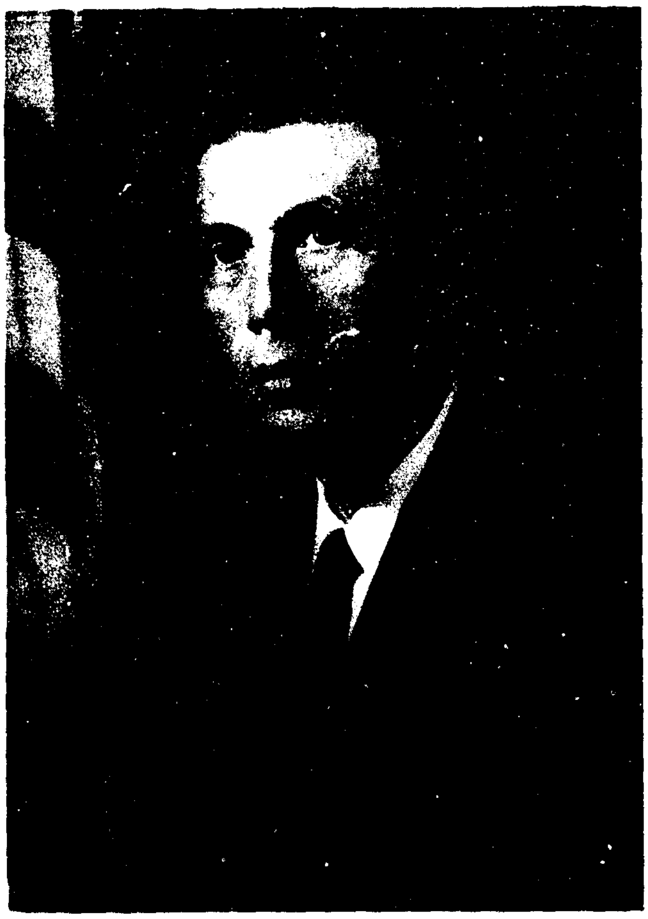
This morning we had the honor of being welcomed by the Under Secretary of State for Political Affairs, The Honorable U.Alexis Johnson. The Secretary of the United States Air Force, the Honorable Robert C.Seamans, Jr, the Permanent Representative of the United States to the North Atlantic Council, the Honorable Robert Ellsworth and the Vice Director of the International Military Staff of the North Atlantic Treaty Organization, Lt General Theodore R.Milton spoke to us about the environment in which defense research and development finds itself today. Their remarks were topical, frank and greatly appreciated by all of us. That would seem honor enough for one day, but many of us have come a long way and wish to absorb as much as we possibly can before we return to our nations.

This afternoon, the AGARD National Delegate from the United States, Mr Grant L.Hansen, has been kind enough to organize a program on the United States aerospace research and development program. So, I would now like to turn the meeting over to Secretary Hansen, the United States Air Force Assistant Secretary for Research and Development. Secretary Hansen.

INTRODUCTORY REMARKS BY THE ASSISTANT SECRETARY FOR RESEARCH AND DEVELOPMENT, UNITED STATES AIR FORCE

The Honorable Grant L.Hansen

Thank you Dr Benecke, National Delegates, AGARD members, distinguished guests. I am delighted by the fine attendance to this 6th AGARD Annual Meeting. I join the other two US National Delegates in saying how proud and pleased we are to have you here. We look forward to the rest of the activities and hope that your stay will be both memorable and productive. Before introducing the speakers of the afternoon, I would like to present my other two associates that are the National Delegates from the US. First, Dr Al Flax who was my predecessor as Airforce Assistant Secretary for Research and Development and who is no stranger to this group. He has had a long and distinguished career in the US Research and Development activities. He is a graduate of the Guggenheim School of Aeronautics at New York University and received his Ph.D from the University of Buffalo. He has served as Vice President and Technical Director of the Cornell Aeronautical Laboratory, as the Airforce Chief Scientist, as a member of the Airforce Scientific Advisory Board, and is currently the President of the Institute for Defense Analysis. Dr Flax received the Lawrence Sperry award of the Institute of Aerospace Science for his contribution to the advancement of aeronautics. He has also received the Airforce Exceptional Civilian Service Award of the United States Air Force. I would like at this time to ask Dr Flax if he would like to say a few words about his participation in AGARD.



Dr Alexander H. Flax

Thank you very much. I would like to add my welcome to that of Secretary Hansen to my fellow members of the National Delegates Board to say how happy we are to have you here and to welcome all the other guests who have come to this meeting. It has become something of a tradition that the US representation on the National Delegates Board will consist of a triumvirate; one representative from the DOD, one representative from NASA, and one representative from the technical and scientific community at large. It is this latter role which I now find myself fulfilling and, if I may be permitted, I would like to say just a few words about the aspect which the scientific community in the US sees in AGARD. There have been many questions raised as to the value or the validity of AGARD's activities, and I would not undertake to argue for or against any of the desiderata for an organization of this type, I would merely like to say that since its inception the AGARD organization has been held in very high regard by the scientific and technical community of the US and is still held that way. It is considered highly desirable to participate in AGARD activities; AGARD publications and AGARD meetings are often the source of basic information which strangely enough, even in as large and diversified a technical society as we have in the US, do not come to light otherwise, and AGARD publications are often basic references in certain fields of activity. I would particularly like to say one more thing without again detracting in any way from the desire to see immediate military results coming out of AGARD activities at the senior political military levels. I would like to refer to something of a nursery rhyme that I learnt many years ago and it was "that for want of a nail the shoe was lost, for want of a shoe the horse was lost, for want of the horse the rider was lost, and for want of the rider the battle was lost", and I would say that up to now we in AGARD have been concerned with the nails and the shoes. The airplane wing that didn't break off because of fracture mechanics or excessive loading, the tail that didn't break off because of flutter, the drag that was not 20% high, or the inlet that didn't stall the engine, that is not very visible from political or military levels but is very important and I think that all of us in the US that have been concerned with that kind of activity have felt that a very real and meaningful way AGARD has helped us and our allied nations avoid that kind of difficulty and foresee problems and take the necessary steps in advance and that is so often the difference between winning and losing the battle.

Mr Grant L. Hansen then introduced Mr Neil Armstrong

Now let me introduce an individual who has recently become a member of the AGARD family but who also is no stranger to you. He is a graduate of Purdue University and has a M.Sc. degree from the University of Southern California. He has a distinguished record as an aeronautical research pilot, and in addition as a naval aviator, he flew 78 combat missions during the Korean action. He is currently the Deputy Associate Administrator for Aeronautics, NASA Headquarters. He is the recipient of many special honors and degrees. These have included among others the Presidential Medal for Freedom, the NASA Exceptional Service Medal, the Robert H.Goddard Memorial Trophy, the Collier Trophy and the General White United States Air Force Space Trophy. He is best known to the world as the spacecraft commander of Appollo 11 and the first man to walk on the surface of the moon. Our goal for him is to become known as a leader in the aeronautics field and a National Delegate of AGARD as well as he is for his previous achievements. Neil Armstrong.

Mr Neil Armstrong

Thank you very much for that very warm welcome and acceptance. It is a great pleasure for me to be here to represent NASA in the triumvirate and also to join this very distinguished group of National Delegates. I have been to almost every one of the nations represented here at the table in the past year and I am very pleased to see old friends, friends that I have met recently in that year. I have a new responsibility now in aeronautics as was mentioned but have been side-lined during the past 8 or 9 years on a small project and have not had the benefit of meeting with you gentlemen; however, I am not a stranger to AGARD. I have participated in AGARD meetings before and some of my friends were pointing out at lunch papers they remembered I had given in earlier days to AGARD and are still criticizing and in any case, this experience of the past 9 years has been to me an interesting and useful one; it has been a program in which people of many interests have come together, people from aeronautics, from space, from science, from geology, from medicine. It is a so-called interdisciplinary approach. That is a favorite word these days. It only means that people who don't normally get together do so and in the same light AGARD serves a similar purpose. It gets people who don't normally get together, together and allows them to discourse on subjects of mutual interest. I look forward to the opportunity of participating in that discourse in the coming years. I look forward to my challenge as building a strong aeronautics program. I look forward to meeting you individually in your respective countries with respect to that and our aeronautics program and I especially look forward to being able to have the privelege of joining you as a member of the National Delegates to this group. Thank you very much.

Mr Grant L. Hansen then introduced Dr John Foster

It has been the custom for the host nation during the AGARD Annual Meeting to share its thinking and activities in Aerospace Research and Development. We are indeed fortunate to have three extremely well qualified speakers with us this afternoon who represent successively the Department of Defense, NASA, and the US Air Force. It is my great honor to introduce Dr J.S. Foster, Jr, Director of Defense Research and Engineering as our lead-off speaker. Dr Foster has served for over two decades in key US research and development positions. He has made major contributions in the fields of radar, radar counter measures and nuclear energy and weapons. He has served as the Director of the Livermore Lawrence Radiation Laboratory. He has been a member of the Army Scientific Advisory Panel, the Airforce Scientific Advisory Panel, Panel Consultant to the Presidential Scientific Advisory Committee and a past US National Delegate to AGARD. Dr Foster's honours include the Earnest L. Lawrence Memorial Award of the Atomic Energy Commission, the Department of Defense Distinguished Public Service Medal, membership in the National Academy of Engineering and the James Forrestal Memorial Award. I am very pleased to present Dr John Foster whose accolades also include being the youngest looking and most vigorous grandfather I know.

ADDRESS BY THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING, DEPARTMENT OF DEFENSE

The Honorable John S.Foster, Jr

Secretary Hansen, Dr Benecke, members of AGARD and distinguished guests: It is a pleasure and an honor for me to have been asked to meet with you today. I am going to take this opportunity to discuss with you a particular major problem that we all face. I will suggest several possible approaches; I hope, however, that you will accept the challenge to find a satisfactory solution.

It seems to me that many of the greatest problems we face – we, the free nations of the world, and particularly those of NATO – stem from the Soviet development and deployment of major weapon systems. These actions can represent a threat to our collective security. I would like to discuss the Soviet threat, but not that conspicuous one created by the preponderance of Soviet forces – their numbers of aircraft, submarines and ballistic missiles. Instead, I propose to concentrate on what I believe is, in the longer run, an even greater challenge to our security. This challenge is posed by a technological threat from the Soviet Union – their ability to develop and have available for use major weapon systems based on advanced technology.

To maintain our security, I believe it is absolutely essential that the Free World be technologically superior to the Soviet Union. There is no room here for parity – we of the Free World must have this superiority. The reason for this flat statement is that the Soviet Union and the other Warsaw Pact nations are wrapped in a cloak of secrecy that prevents us from learning much of what is going on in their laboratories and industrial research centers during the years prior to weapons testing. The only counter to those early years of secrecy that I can suggest is our possession of a few years' technological lead. That is the balance – technological superiority to offset their secrecy.

I am convinced that today we do have technological superiority. But I am very concerned about the enormous size and momentum of the Soviets' technical effort; its momentum is so great that much of the effort cannot be limited solely to the advancement of technology but must, of necessity, go into the development and engineering of major weapon systems.

Thus, I am concerned about two points – our changing technical position and our future efforts to provide the technology for major weapon systems. I have four charts that will help explain my reasons for concern.

The first chart compares the relative efforts expended by the United States and the Soviet Union in military research and development and civil space activities during the years 1953-1970. The scale for the ordinate is expressed in billions of dollars. In other words, "equivalent effort" is the amount of money the United States would have had to spend in order to get the results obtained by the US or the USSR in each of those years.

It is important for us to know that the Soviet effort is actually the size I have indicated – and not half of it or double it. The error is represented, to the extent we can judge it, by the width of the band surrounding the Soviet curve. Let me tell you why we believe those limits are reasonable.

We have looked at the situation that existed in the Soviet Union during 1960, 1964 and 1968. For many tactical, strategic and space systems, both military and civilian, we asked: How long ago was the United States in the same position as the Soviet Union now seems to be? In other words, we asked how much of a lead we had over them or how far behind did we lag. As the years passed, we gauged whether we had advanced or fallen back

technologically. Our assessment confirmed that the only way the Soviets could have obtained their results was by the expenditures shown. There is no way to deviate from the Soviet curve by more than about 10 percent without unbelievable changes in our estimates of lead status.

Consider the information these curves convey. Note that the Soviet Union increased its efforts at a relatively constant rate – 10 to 13 percent – during this period. The efforts of the United States have not followed a constant slope but, instead, tended to vary. This is illustrated by an observation of two particular time frames.

The first begins around 1957, when the first Sputnik launch occurred. At that time, the Soviet effort was about 70 percent larger than that of the United States. Within two years after Sputnik, the United States had doubled its research and development budget. This level of effort was maintained until shortly after the President decided that the United States would succeed in carrying out the first manned lunar landing. To accomplish this mission, we had not only to increase our total technological effort but to cut back somewhat on the military portion and put major emphasis on NASA's space program. This total program, then, reached a peak in 1966 and 1967.

During the second time frame, the period from 1967 to the present, the US effort leveled off and began to decline. Unfortunately, in my estimation, this is the likely trend for the next few years. It is particularly troublesome because the Soviet Union's technological program shows no indication of leveling off. This possibility, coupled with the absolute magnitude of the current Soviet effort, represents the most critical piece of information conveyed by the assessment.

The second chart separates the two technological programs during the decade 1960-1970 into military and space components. Note that since 1967 the Soviet Union has been sharply increasing its efforts in military R & D.

The third chart shows possible extensions of military R & D and predicts likely trends to 1976. I have assumed that the US will maintain relatively level funding for R & D, recognizing that, because of inflation, this means something like a 5- to 8-percent decline in effort. The Soviet Union, on the other hand, may continue to increase its R & D budget for several years, as represented by the upper dashed extension. If they elect this strategy, or if they choose to increase R & D only in proportion to the increase in their gross national product, the changeover in technological leadership could occur during 1974 or 1975. Then, again, the Soviets may decide to retain their 1970 level of R & D – which is roughly 30 percent larger than the US program now – through the mid-1970s, in which case technological leadership could pass to them late in the decade.

I would like you to consider this fact: If we decided to prevent this crossover of technological leadership, we would have to add approximately $\$5 \times 10^9$ to our R & D program by 1975.

The fourth chart adds to the US and USSR curves current equivalent military R & D efforts of all other NATO countries, which amount to roughly $\$1.25 \times 10^9$. If those nations were to devote the same proportionate share of revenue from their taxpayers that the United States does, of course, the NATO contribution would increase by a factor of 3 to 4, and part of the technological superiority problem would disappear.

If we elect to do nothing to change the situation, if we elect to live with the trends and ways of doing R & D that I have shown, two consequences will surely follow:

First of all, we, collectively, will lose our technological leadership. As I have said, I believe that is totally inacceptable because of the secrecy covering Soviet activities.

Second, in the mid-1970s we will have in the field weapons inferior to those deployed by the Soviet Union. More important, we will not have developed the major new weapon systems that will be required by our forces and that the Soviets will have. And, if not developed, they can't be produced.

I believe there are several factors behind the trends I have discussed. One is that there has been no recent change on the Soviet side. In the open literature they have made it very clear to everyone that they intend to gain technological and military superiority. So the trends are caused by changes in the Free World. For the United States, this trend is partly a consequence of the difficult war in Southeast Asia. It also arises to some extent from the desire of this country's people to do more here at home – to do something about pollution, about poverty, about health, transportation, and a host of other important matters. But, to be entirely fair, I should say that there is also a growing reluctance on the part of the people of the United States to spend more and more money for weapons to protect other nations when they do not see those nations making a comparable effort to protect themselves. There are, of course, many other reasons as well, but these come quickly to mind.

What should we do about it? Let me suggest three obvious approaches and describe the problems that I see are involved.

First, we could continue the way we are going, with a relatively constant R & D budget for the United States, a relatively constant R & D budget for NATO. The difficulty with this attitude is that within a few years the crisis I foresee will occur, and in that crisis we are likely to find ourselves with "too little, too late".

A second approach would be to go to our various parliaments and ask for significantly higher R & D funding. I could, for example, go to the Congress of the United States and ask for $2 or $3 thousand million more in Fiscal Year 1972, another $1 thousand million in 1973, and perhaps even more than that in 1974, and even so, barely track the Soviet Union's progress. The difficulty with this approach is that, even if I could secure the approval of the Executive Branch, I cannot believe that today the Congress could be persuaded to grant such increases either quickly or easily, for the reasons I've given before.

A third approach would be to have the other nations of NATO increase their military R & D budgets to three or four times their present level. That way, collectively, we would equal the corresponding effort of the Soviet Union. I suspect you might have as much trouble in persuading your superiors – and they, your parliaments – as we would in the United States.

Those seem to be three fairly straightforward approaches, but in my opinion they are either unsatisfactory or impracticable. Let us therefore consider another approach. I know that, in the United States – and probably in your nations as well, we have our noses close to our budgetary papers, trying to see how we can save money – trying to avoid starting programs, looking for work we can cancel, and seeing whether we can stretch out programs to reduce current costs. In this environment, there is little room to plan for any new major weapon system.

As a strategy leading to another approach, I challenge us all to take a fresh look at our collective R & D activities and examine them for unnecessary redundancy. Think of all the research and development going on in NATO countries. Aren't some of these programs being duplicated several times over? Isn't the United States itself conducting R & D programs that duplicate most of the other NATO nations' work?

Research and some exploratory development in the US certainly are redundant when viewed from this aspect, and this is probably worthwhile. But in the R & D effort of all NATO nations other than the United States, which amounts to something like $\$1.25 \times 10^9$ each year, there may be as much as $1 thousand million of overlapping work. If this degree of redundancy is unnecessary – and that may well be the case, it will contribute to the growth of the anticipated technological threat in the coming years. Removing that redundancy, of course, would take care of only a fraction of what we need to match the predicted technological challenge of the Soviets – we are looking for several times that amount of money. But that's one place we can start.

My other suggestion is that we look up from the fine print in the papers we are examining and decide what programs must be started in order to maintain the balance of power. There are ways to do this, and the programs could be completed with technology that is in hand. They would, however, take a certain boldness, a conviction that we are going to do something about this untenable situation. I am not going to list those programs for you, but I will ask some leading questions.

How long has AGARD studied air defense in Europe? Have we a good air defense program now? Do you think we have the right developments to provide for NATO's air defense?

How long have we looked at the problem of passive defense – the defense of aircraft on fields? Is that too tough a technological problem? Have we solved it? Is the defense of those aircraft in hand?

How about an air-to-air fighter? Have we solved that problem technologically – not only the airframe but the whole weapon system and the black boxes that will keep the airplane flying when it faces a combination of SAMs and antiaircraft artillery? Surely we can deal with either of those by itself, but have we solved the problem of their combined threat, not only in a technical sense but with existing hardware?

What have we done about survivable command, control and communications? Have we got such a system – or is the right program going forward toward that goal?

What are we doing about the individual soldier, the man who has to stay alive on the battlefield, the man who must fight? Have we a program for him?

Those of us who knew Theodor von Kármán recognized his great love of science and technology, and saw his incessant efforts to encourage young men to enter that field of work. But Professor von Kármán also gave particular attention to ensuring that the products of research and technology were used for the security of the Free World. It was here that he probably made his major and lasting contributions.

It seems to me that we are once more in the kind of situation that Professor von Kármán faced in the 1940s and '50s. I believe we are challenged to exert greater efforts toward solving crucial military problems so that we can preserve the balance of power in the face of the trends about which I am so concerned. It is time that we followed von Kármán's lead and did what he found absolutely essential in his lifetime. We must make sure that we use our scientific and technical abilities to change the course of threatening international trends in R & D, restore our technological eminence, and provide the inventory of systems that we need to ensure the security of the Free World.

Thank you.

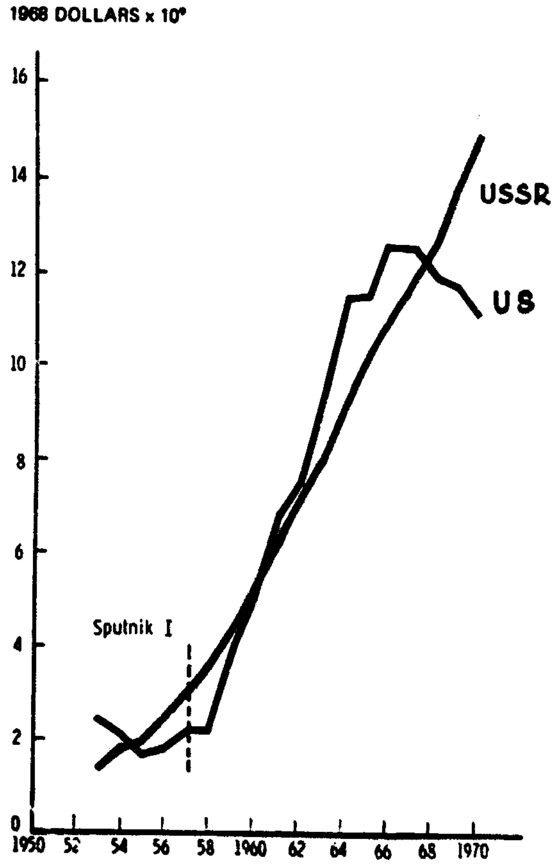


Chart 1 TECHNOLOGICAL EFFORTS

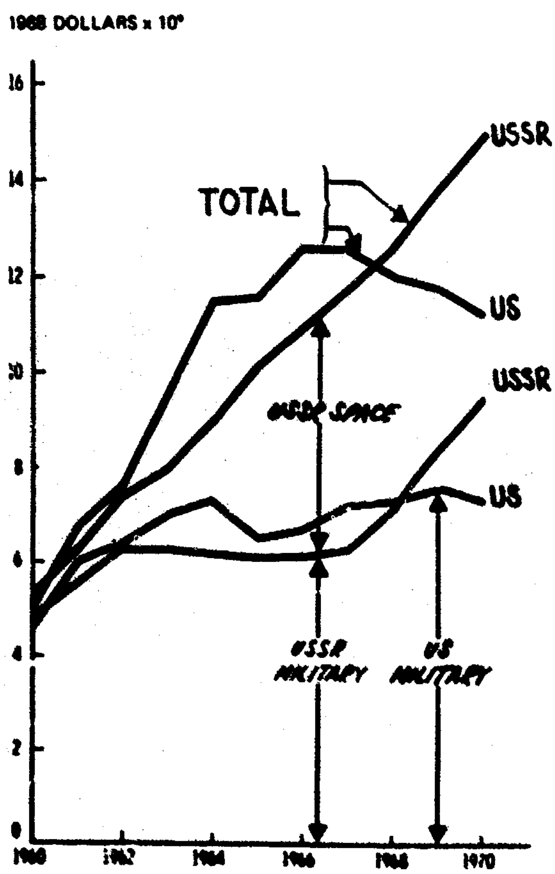


Chart 2 TECHNOLOGICAL EFFORTS

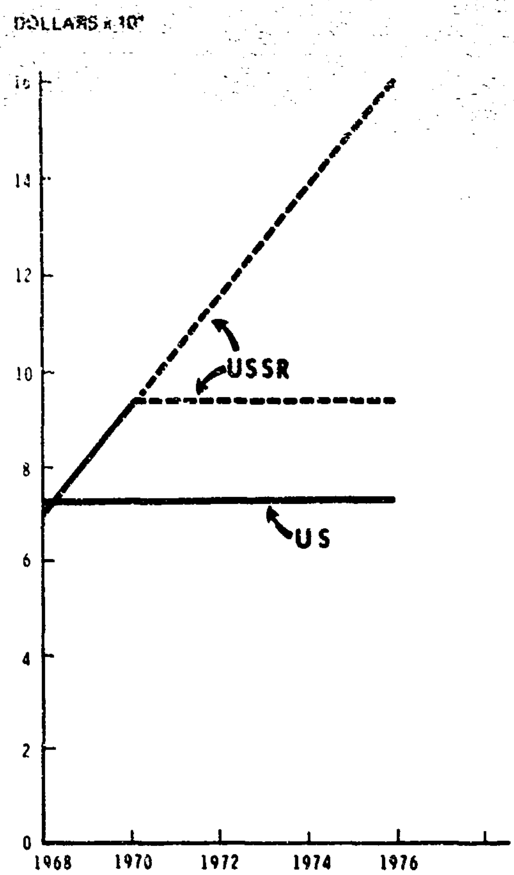


Chart 3 1968-1976 POSSIBILITIES

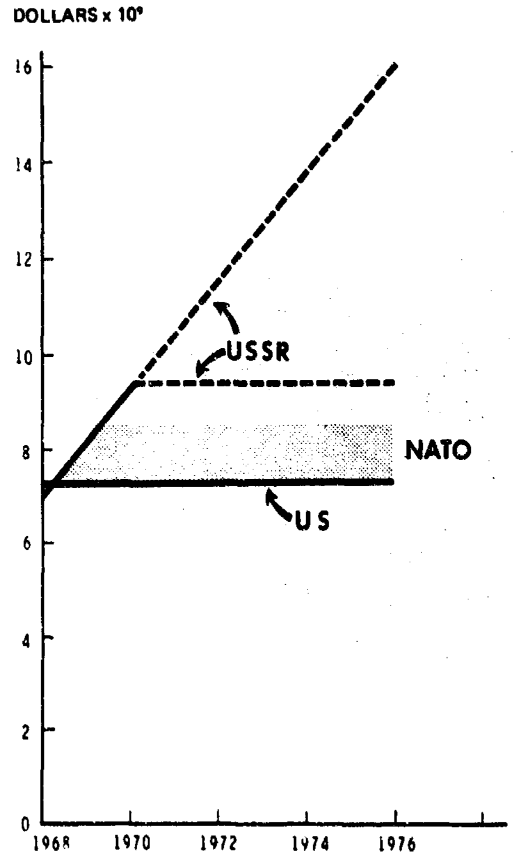


Chart 4 1968-1976 POSSIBILITIES

Mr Hansen thanked Dr Foster for his speech:

Thank you, Dr Foster, for a most illuminating and challenging message.

Mr Grant L.Hansen then introduced Mr Milton B.Ames, Jr

Our next speaker – from the National Aeronautics and Space Administration – in addition to a distinguished career in advanced research in the fields of aeronautics and space technology has participated widely in international research and development activities. He has served as a US representative in the AGARD Fluid Dynamics Panel, and for many years he has served as the NASA Special Assistant to the US National Delegates to AGARD. Mr Milton B.Ames is currently the Director of Space Vehicles in the Office of Advanced Research and Technology in the Headquarters of the National Aeronautics and Space Administration, or NASA. He received his Bachelor of Science degree in Aeronautical Engineering from the Georgia Institute of Technology. He began his career after graduation from college as an aeronautical research engineer at the Langley Research Center of the then National Advisory Committee for Aeronautics, or NACA. He quickly progressed to increasingly more important positions in the NACA and has spent most of his career in Washington staff positions of the NACA and later NASA. Mr Ames is the author of many technical publications in the areas of flight mechanics and aerodynamics. He is a Fellow of the American Institute for Aeronautics and Astronautics. It gives me great pleasure to present Mr Milton Ames.

ADDRESS BY MR MILTON B.AMES, JR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr Milton B.Ames, Jr

My role at this Sixth Annual Meeting of AGARD is to present highlights of NASA's recent activities and accomplishments, and to indicate some of our future plans.

I recall that when AGARD held its Seventh General Assembly in Washington in 1957, the National Aeronautics and Space Administration simply did not exist. You saw the perturbation on Dr Foster's curve when we came into being. However, NASA has continued the NACA tradition of supporting AGARD by the exchange of information on the science and technology of flight.

We value highly the opportunities AGARD affords us to meet and to discuss activities on a personal basis with workers in other member countries. Through AGARD, we have established strong bonds of lasting friendship and mutual respect because of our many common interests in Technology.

As stated in the United States National Aeronautics and Space Act of 1958, one of our principal objectives is:

"The improvement of the usefulness, performance, speed, safety, and efficiency of aeronautical and space vehicles."

Hence, our programs in research and advanced technology are directed at the accomplishment of these objectives, and my first figure helps to describe how these programs evolve. This chart indicates the steps in NASA's Research and Advanced Technology Cycle.

Although this whole process – or research and technology cycle – is well understood by AGARD's panel members, it is shown here because I shall use it later to describe examples of NASA's activities.

In the first two steps, for example – *Research* and *Advanced Technology* – we seek new knowledge in all of the aerospace disciplines.

Next, in *Focused Advanced Technology*, we conduct well-organized multi-disciplinary programs to develop advanced concepts and missions.

Under the heading *Supporting Technology* we direct our efforts at the development of specific aerospace vehicles.

My next chart shows the nature and scope of NASA's Aeronautical Vehicles Program. This program is receiving new emphasis and expanding as rapidly as personnel and other resources become available. Now I will depart from my text because in recent months two people, Mr Oran Nicks the acting Associate Administrator for our section of NASA and Mr Armstrong who spoke to you earlier have both been concentrating efforts to expand our work in this area. So I believe I can tell you that the chart is only representative and does not give you a full picture of the program. However, you can see that advanced research and technology activities encompass all disciplines, while the focused technology programs are concerned with all classes of aircraft from general aviation to supersonic and hypersonic vehicles, and both civil and military applications. I want to discuss several examples using the steps in the research and advanced technology cycle to explain how new concepts grow out of generalized disciplinary research.

The supercritical airfoil shown at the top of the next figure resulted from basic aerodynamic research to delay the drag rise usually experienced by airfoils when the local airflow approaches the speed of sound. The supercritical airfoil is shaped so that the shock forms very close to the trailing edge and most of the separated flow is eliminated.

In the middle sketch, the results of basic airfoil research are applied to an idealized three-dimensional supercritical wing-body configuration.

An advanced technology program to investigate this configuration verified the potential improvements indicated by earlier research and analyses. These studies showed such promise that we have planned a focused advanced technology program to investigate the feasibility of the supercritical wing-body concept in flight, as shown on the lower portion of the figure.

The supercritical wing-body concept may lead to attainment of higher aircraft speeds before encountering the drag rise, and significantly reduce buffet caused by separated flow. In a similar manner, it is expected that maneuverability of combat aircraft may be substantially increased. Other analyses indicate that the concept may also increase the cruising speeds of conventional jet transports say approximately 10 percent to perhaps as much as 17 percent.

In summary, the broad goal of this advanced technology program is focused to achieve more efficient flight very near sonic speeds.

Another principal area of emphasis in the Aeronautical Vehicles Program is related to V/STOL aircraft. This activity is quite broad, covering fundamental work on high-lift devices, stability and control and handling qualities, propulsion systems, and vehicle configurations.

The next figure illustrates a promising concept for providing jet-powered aircraft with STOL capability —the jet augmentor wing. It is evident from the figure that here we have another example of the orderly steps of the research and advanced technology cycle.

Basic disciplinary research conducted in 1966 and 1967, as shown at the top of the chart, indicated the potential of the augmentor-wing concept. In this high-lift device, engine air is directed through the wing and ejected ahead of the flap. The resulting flow of air over the flap acts to delay separation of the external airflow over the wing and to augment the lift by directing the flow downward.

These basic studies led to an advanced technology program beginning in 1967. Here a large-scale wind-tunnel model was tested in the Ames Research Center's 40- by 80-foot wind tunnel, as indicated by the photograph in the middle of the figure. A substantial increment in lift was obtained in these tests, and this offered promise of greatly decreased landing and take-off speed of jet-powered aircraft.

Accordingly, an augmentor-wing design feasibility study was undertaken in 1969. Because of the promising results obtained, a flight investigation is now planned using a C8A aircraft. The aircraft will be modified to incorporate the jet augmentor-wing flap in a joint research program with our associates in Canada. The flight investigations of this promising high-lift wing for STOL aircraft should begin during 1971.

Supersonic aircraft technology is the area receiving the most attention in NASA's Aeronautics Program. Our objective is to provide advanced technology for development of configurations that will lead to the realisation of safe and efficient supersonic aircraft again for both civil and military applications, and improved performance for military aircraft in support of military objectives.

The large size and unconventional shapes of supersonic transports lead to unusual inertial and aerodynamic characteristics that cause difficulties in providing adequate stability and control. The next chart shows NASA's new Flight Simulator for Advanced Aircraft, which was recently put into operation at the Ames Research Center late in 1969.

Because of its unique capabilities, the simulator is being used to develop supersonic design criteria to overcome these difficulties alluded to as a part of a cooperative research effort with the Federal Aviation Administration. The basic goal of the simulator is to provide the pilot with all the cues that he needs to assess the response characteristics of the airplane. For many tasks, motion cues are of overriding importance.

The notable departure of this flight simulator from earlier simulators is in the very large side travel or allowable lateral motion up to 100 feet; other travels of 10 feet vertically and 8 feet fore-and-aft are more modest, but still appear to be adequately matched to the side travel. Rotational motion is provided about all three possible axes to reproduce any desired resultant motion.

A screen for visual display is provided, and attention has been given to providing accurate variations of control forces, instrument arrangements, and engine noises, as well as the general cabin environment. A large-capacity digital-analog computer continuously computes the airplane responses and actuates the various systems, providing flexibility and accuracy in the simulator operation.

During the cooperative NASA/FAA research effort, low-speed flight characteristics of the Concorde were assessed. Both British and French pilots flew the simulator during these tests. It was concluded that the simulator duplicated quite well the low-speed characteristics of the Concorde. Studies of supersonic handling qualities of the Concorde and other SST configurations are planned on the simulator later this year.

A short film illustrates the operational features and capability of this new flight simulator. A landing sequence is also shown which demonstrates some of the maneuvers that the pilot would perform as he flies the airplane throughout the demanding requirements for a precision high-speed approach and touchdown.

* * * * * *

Now, I want to make some brief comments on NASA's Space Vehicle Research and Technology Program. First, however, I think it is fitting at this point to quote a prediction made by Dr Theodore von Kármán, the father of AGARD. In 1958, when the United States decided to expand its activities in space, there were many who felt that space flight technology, which was an outgrowth of our missile programs, was far removed from aeronautics. However, Dr von Kármán could foresee and predict the future better than most men. He said, and I quote:

> "Those who say that all that men teach and all that men investigate, under the name 'aeronautical engineering', is obsolete, seem to assume that by some miracle the designers of space vehicles will not encounter problems involving such classical sciences as fluid mechanics, structures, materials, and vibrations. I am sure that this will not be the case."

During the past several years, we in the United States have been developing our plans for the post-Apollo era. From these plans, I have selected an example in our space vehicle research and advanced technology program which I believe demonstrates the truth of Dr von Kármán's statement. Here, also, you see once again the orderly steps from disciplinary research and advanced technology, to focused advanced technology, and – finally – supporting technology.

Now my next figure shows two photographs which represent disciplinary-oriented high-speed aerodynamics research, to investigate problems of aerodynamic heating during atmospheric entry. Our goal is to develop the basic and applied technology that will permit the design of space vehicle configurations that will survive the intense heating during atmospheric entry, maneuver at hypersonic speeds, and be piloted to a safe landing on land.

Many configurations have been investigated and substantial high-speed, high-temperature atmospheric entry data are now available. However, one of the most important aspects of flight with lifting-entry vehicles of this class is their unusual flying characteristics during the terminal phase of flight and landing.

This fact prompted us to conduct a preliminary investigation at NASA's Flight Research Center to study the low-speed flying qualities and landing problems of a very lightweight lifting-body configuration in 1963. The success of this investigation led to a cooperative NASA/USAF flight research program early in 1964, to investigate the subsonic, transonic and supersonic piloting characteristics of these unorthodox vehicles at more realistic weights and flight conditions.

The next figure shows these three vehicles being investigated in the NASA/USAF Lifting-Body Flight Research Program. They are, from left to right, the US Air Force X-24A, the NASA M2-F3, and the NASA HL-10. Flight testing has been underway since July 1966. We have successfully completed a total of 72 flights and have achieved a maximum Mach number of 1.8 at an altitude of 80,000 feet with the HL-10. Recently, the HL-10 was used on two occasions to obtain flight experience during powered approach and landing.

The program is continuing to provide valuable information on subsonic, transonic and supersonic flying qualities, and the vehicles will also be used for research on advanced control systems, reaction controls, comparisons of aerodynamic and reaction control, rate command, and possibly, fly-by-wire techniques. Valuable operating experience has already been gained and will continue to be one of the primary objectives of the flight research program.

I have a short film showing a research test flight of the HL-10.

The vehicle is air launched from a B-52 mother ship at an altitude of about 40,000 feet. It is accelerated by an 8,000 lb-thrust rocket engine to the desired Mach number and altitude. You will have an opportunity to see approach and landing operations, first from the chase aircraft, then from the ground, and finally, through the cockpit window.

Now my next figure compares the Saturn V launch vehicle on the left with four space shuttle configurations being considered for the post-Apollo program and it is apparent that aeronautical technology and space technology are converging as both advance, and the truth of Dr von Kármán's statement a decade ago should be clearly evident.

We in NASA and our associates in the Air Force are conducting a highly organized and focused mutli-disciplinary advanced technology program to make such advanced space vehicle systems a reality. With the support of our President, we have invited other nations to join us in the post-Apollo program and make it a truly cooperative international effort.

* * * * * *

At the Fifth AGARD Annual Meeting in Bad Godesberg last year, we presented a report and film on the successful accomplishment of the Apollo 11 lunar landing mission. Because of the success of Apollo 12 and the interest expressed in the results obtained, I shall now present a sound film report on the Apollo 12 mission.

* * * * * *

PLANS FOR THE FUTURE

Today we, as engineers, scientists, researchers, and statesmen, ask "But what of the future of flight technology?"

Shakespeare said, in "The Tempest",

> ".....whereof what's past is prologue, what's to come is yours and my discharge."

I reviewed briefly our continuing activities in aeronautical research and plans for the space shuttle. There are also plans for the future to continue to explore the planets. However, I think it particularly appropriate at an AGARD meeting to comment on man's future role in aeronautical and space flight.

The next chart shows the principal areas and objectives of our Human Factors Research programs, which are in support of NASA's goals to develop a better understanding of man and his requirements for supporting equipment to enhance his performance, in both space and aeronautical operations.

The next chart shows how we are studying crew dynamics in isolation, such as in long-duration space missions. Here, in the "man-machine integration area", NASA is playing a major role in the Tektite II project, in which small groups of men live and work in an undersea habitat for periods up to sixty days. This provides an analog for studying the behavior and relationships of men assigned to an isolated vehicle.

My next figure shows the space station simulator used in the 90-day manned test to develop advanced oxygen and water regeneration technology. In this aspect of the life support area, we have just completed a 90-day program with four men in a closed cabin. Water requirements were met by recovery and purification of cabin condensation, wash water, and urine. Oxygen was supplied by regeneration from exhaled carbon dioxide. No supplies or equipment were moved into or out of the chamber during the 90-day test period. The results are now being analyzed, and will be published in the near future.

Now both of these human factors programs are focused on determining man's performance and support requirements for future missions involving use of orbiting space stations.

A short film on Skylab 1 will explain some of these plans to you.

* * * * * *

I hope that this presentation has given you a clearer understanding of some of NASA's efforts, accomplishments, and future plans in aeronautics and space. In closing, I want to quote Dr Hugh L.Dryden, who was not only NASA's first Deputy Administrator, but also (with Dr von Kármán) one of the first US National Delegates to AGARD.

Commenting on the impact on man of progress in aeronautical and space science and technology, Dr Dryden said:

> "None of us knows what the final destiny of man may be – or if there is any end to his capacity for growth and adaption. Wherever this venture leads us, we in the United States are convinced that the power to leave the Earth, to travel where we will in space, and to return at will, marks the opening of a brilliant new stage in man's evolution."

STEPS IN NASA RESEARCH AND ADVANCED TECHNOLOGY

RESEARCH	● UNDERTAKEN IN ALL DISCIPLINES • TO ADVANCE KNOWLEDGE AND UNDERSTANDING • TO SEEK NEW IDEAS
ADVANCED TECHNOLOGY	● UNDERTAKEN IN ALL DISCIPLINES • TO EXPLORE NEW IDEAS • TO SEEK NEW CONCEPTS AND INNOVATIONS
FOCUSED ADVANCED TECHNOLOGY	● ADVANCED MISSION STUDIES ● MULTIDISCIPLINARY PROGRAMS ● FEASIBILITY OF NEW IDEAS AND CONCEPTS
SUPPORTING TECHNOLOGY	● SUPPORT DEVELOPMENT OF SPECIFIC VEHICLE SYSTEMS AND ACCOMPLISHMENT OF MISSION OBJECTIVES ● SOLUTION OF SPECIFIC CRITICAL PROBLEMS

Figure 1

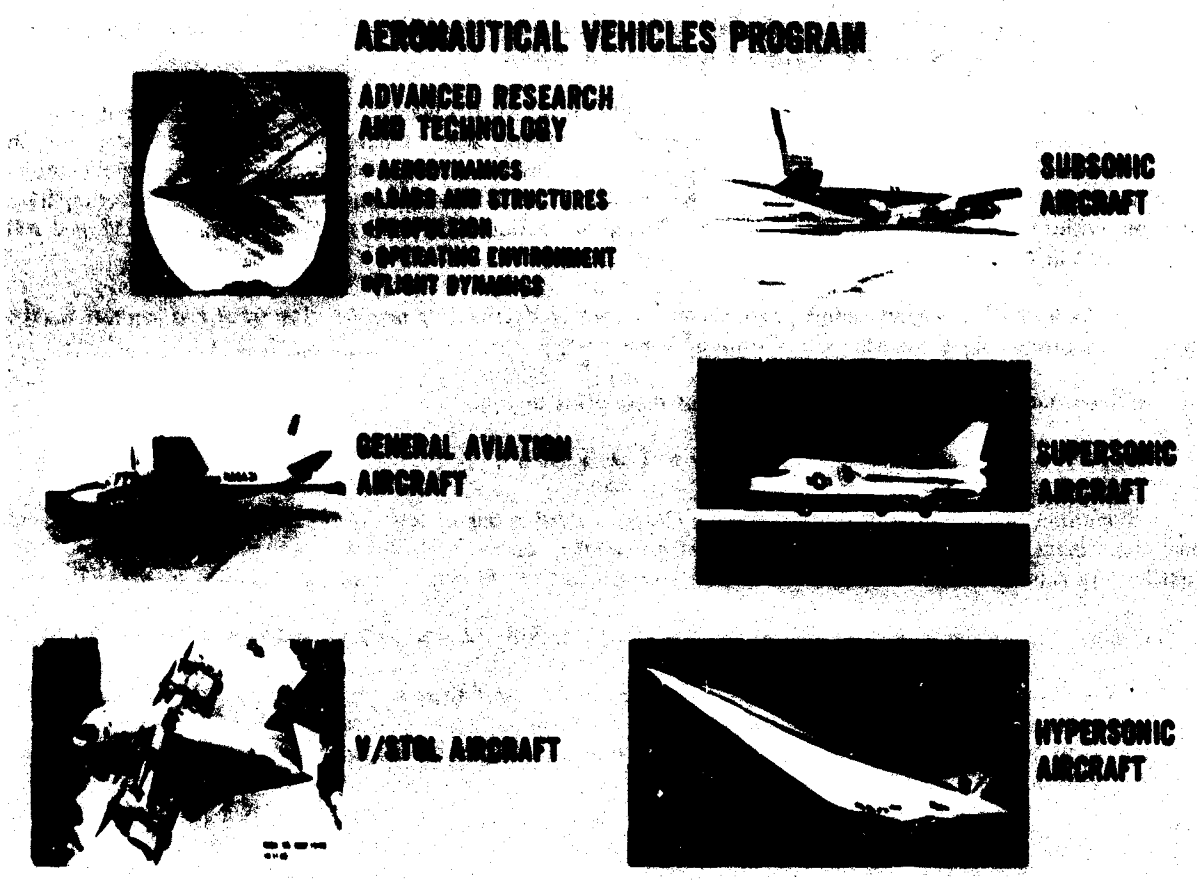


Figure 2

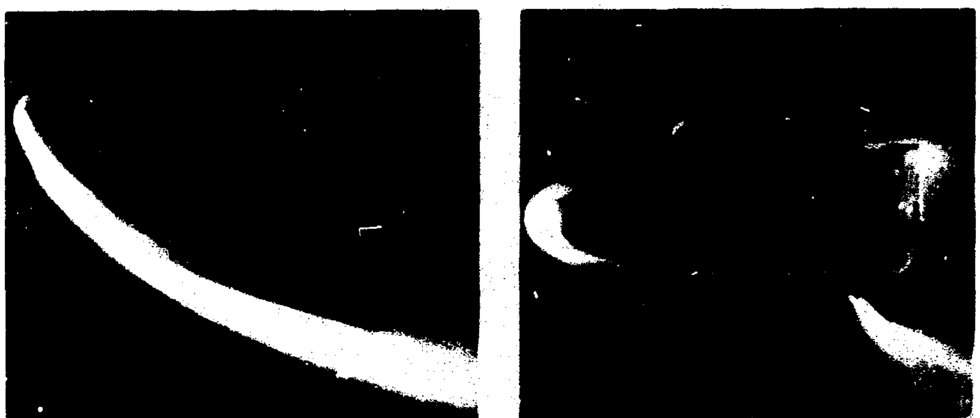
Figure 3

Figure 4

FLIGHT SIMULATOR
FOR
ADVANCED AIRCRAFT

Figure 5

LIFTING BODY AERODYNAMIC HEATING



LANGLEY HL-10 **AMES M-2**

Figure 6

LIFTING BODY FLIGHT PROGRAM
LOW SPEED FLIGHT PROBLEMS

- Subsonic & transonic flying qualities
- Control systems research
- Powered approach & landing
- Operational experience

Figure 7

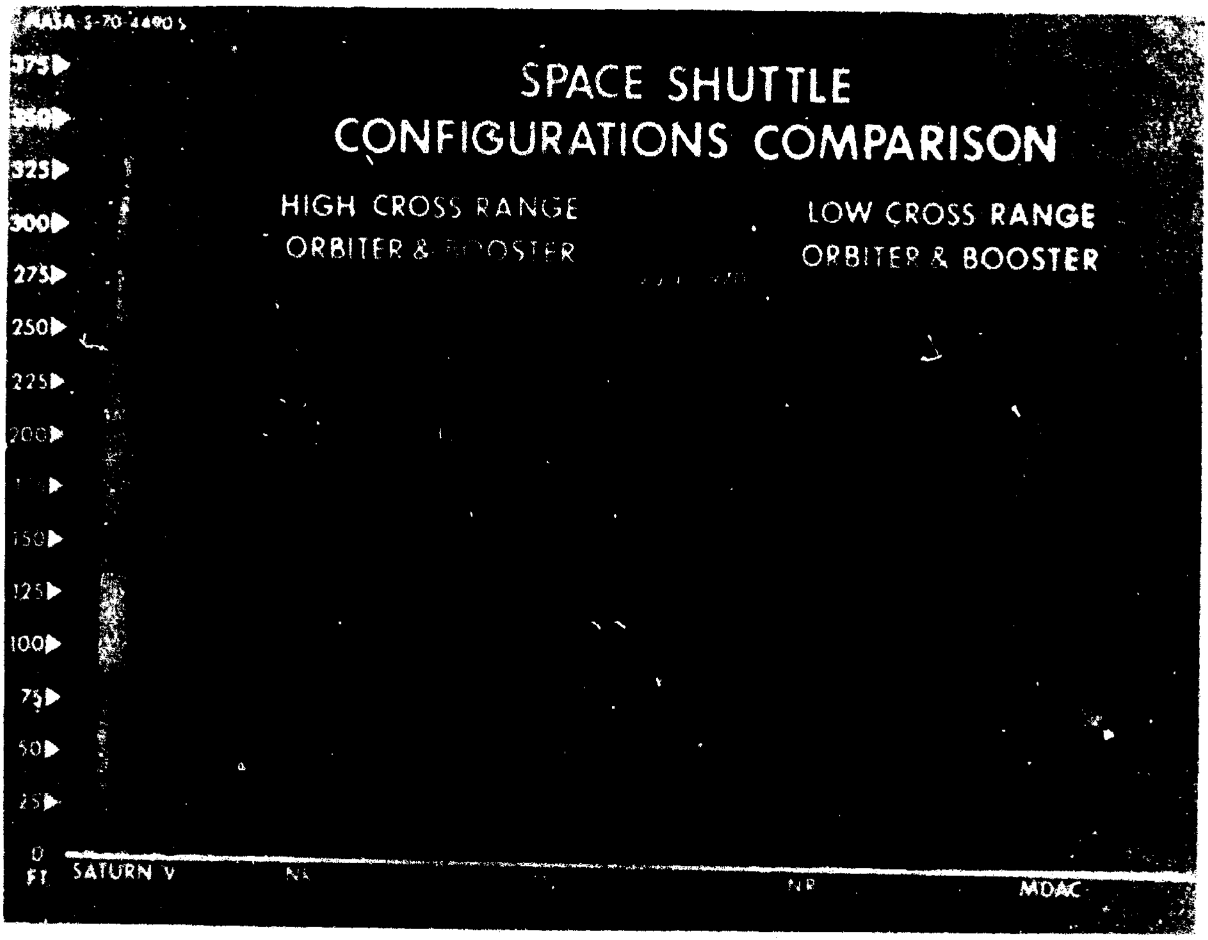


Figure 8

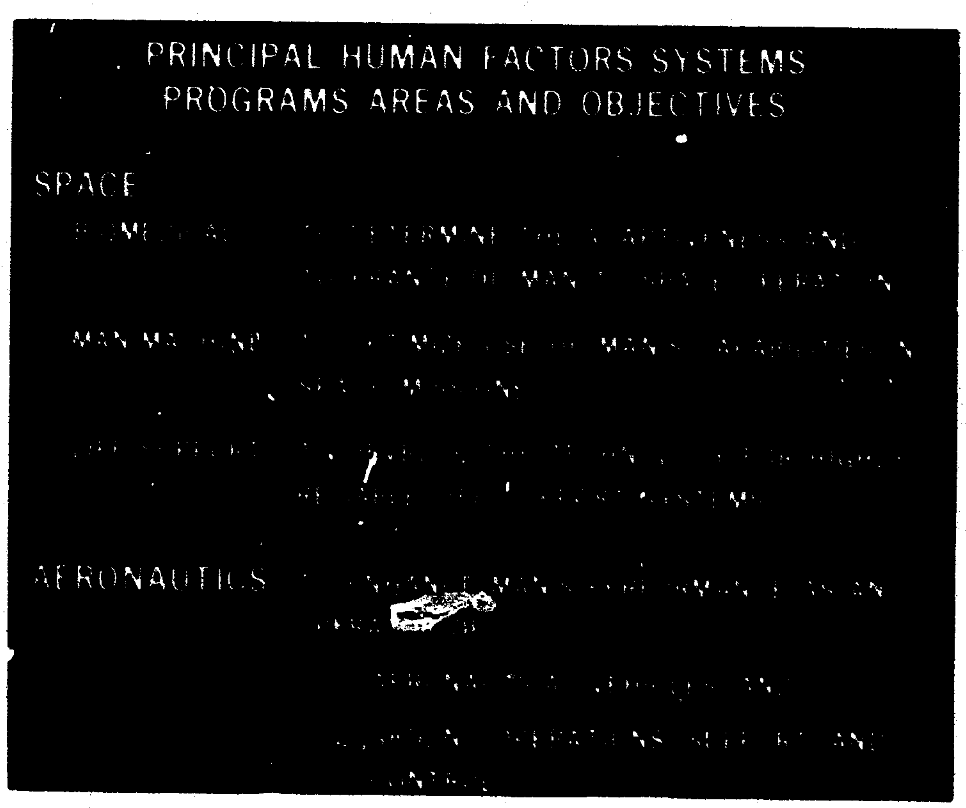


Figure 9

STUDYING CREW DYNAMICS IN ISOLATION

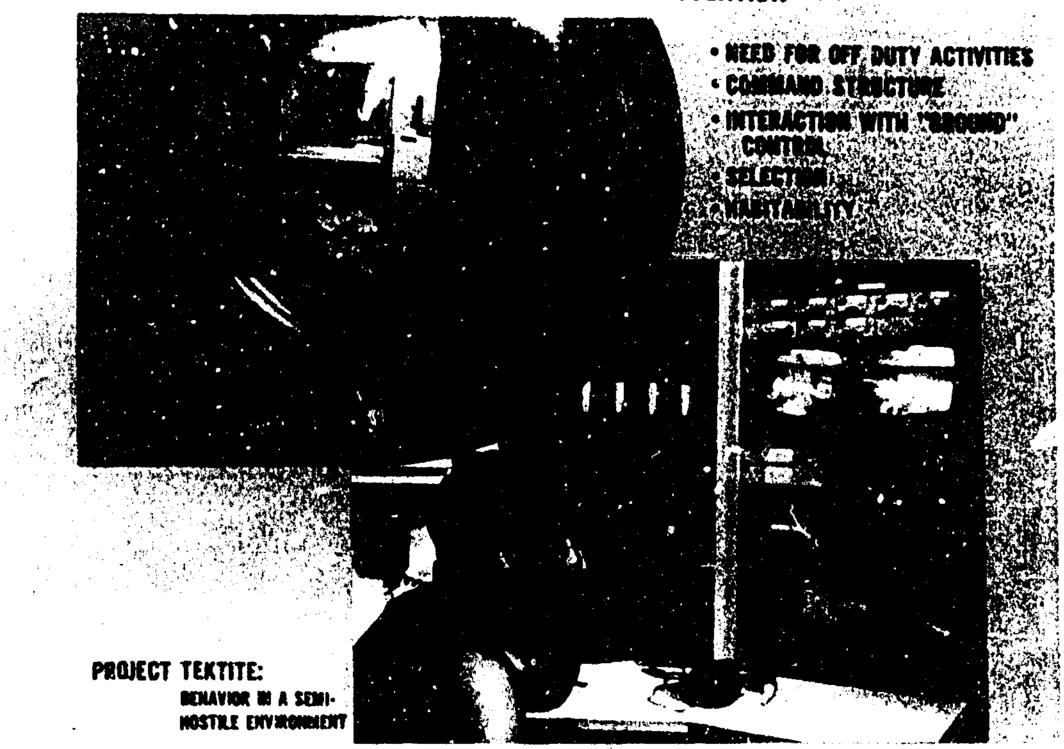


Figure 10

90 DAY MANNED TEST

... ADVANCED OXYGEN & WATER REGENERATION TECHNOLOGY

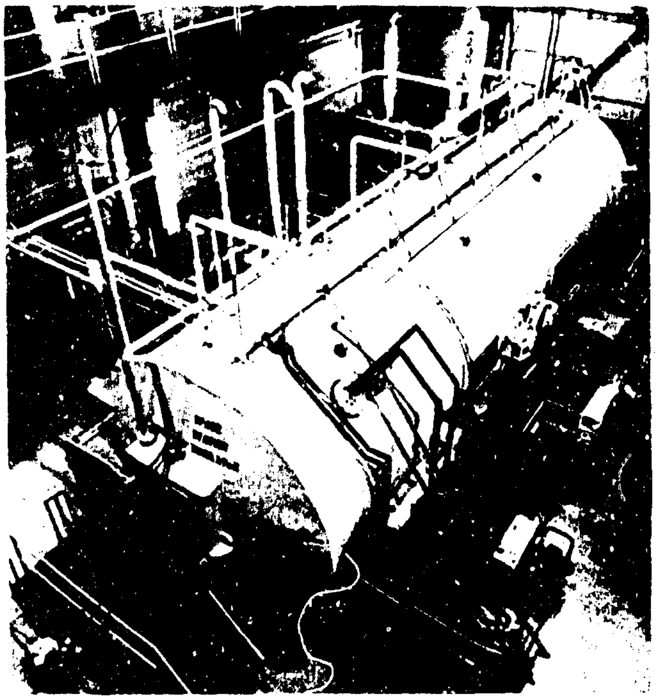


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Figure 11

Mr Hansen thanked Mr Ames for his speech:

Thank you Mr Ames for a most stimulating presentation on NASA aeronautical and space activities and your future plans.

Mr Hansen then introduced Lt General Otto J.Glasser

Our final speaker of this session is Lieutenant General Otto J.Glasser, who is the Deputy Chief of Staff/Research and Development of the US Air Force. General Glasser's distinguished career in Air Force research and development has encompassed almost thirty years. He graduated from Cornell University with a degree in electrical engineering and from the Ohio State University with a master of science degree in electronics and physics. His initial contributions to the Air Force were in the areas of early warning radar. As a lieutenant colonel, General Glasser was selected as one of the initial group to develop the first intercontinental ballistic missile.

He later became Program Director for the Atlas and Minuteman Missiles. General Glasser has served as the Vice Commander of the Electronic Systems Division of Air Force Systems Command and was Assistant Deputy Chief of Staff, Research and Development in Air Force Headquarters until he assumed his present position early this year. Among his decorations are the Distinguished Service Medal, the Legion of Merit, and the Air Force Commendation Medal.

It gives me great pleasure to present General Glasser the Air Force's Deputy Chief of Staff for Research and Development.

ADDRESS BY THE DEPUTY CHIEF OF STAFF, RESEARCH AND DEVELOPMENT, UNITED STATES AIR FORCE

Lieutenant General Otto J.Glasser

1. Opening Remarks and Introduction

Chairman Benecke, Mr Hansen, Members of AGARD, and Distinguished Guests, it is, indeed, my pleasant task to provide you some of our thoughts on Air Force R & D for the Seventies.

It is well, however, before undertaking such a task to remind ourselves who we are and what should be our major tasks for the Seventies: The United States, NATO, and, indeed, the entire free world, like it or not, is faced with a technological challenge unparalleled in modern times.

A detailed or lengthy enumeration of Soviet equipments and forces will certainly be no news to you. Suffice it to say that any objective view of that threat is a sobering one indeed.

She and her satellites have produced weaponry almost everywhere equal to our own regardless of the sacrifices of her peoples.

She has done this with her own resources and with almost no cooperation with the rest of the world. Let me briefly review these feats.

First of all she has built a first class navy in only twenty years while developing the most modern and extensive single flag merchant marine fleet in existence.

Her progress in military aviation has been prodigious. It is often lost in the clutter of conversation about missiles and satellites, MIRV's and FOB's and the like, that the Soviets carefully shepherd a powerful bomber fleet quite close to their hearts and by some accounts, which I happen to believe are factual, she is pressing on with the development of even a new bomber fleet. In the final analysis, it is still the bomber which can come in low and drop one down your chimney.

Let me dwell for a moment on the Soviet's activities with fighter aircraft. She has a fleet of fighter aircraft that is immense by any standard and, if flexibility and dispersed operations are important to a modern Air Force, the Russians seem to agree. I can count three separate types of STOL airplanes, at least one VTOL and two with variable geometry in her fighter inventory. Lastly, let me say that, by any analysis, the MIG-23 shows every evidence of being one of the world's finest air superiority fighters.

These days, a discussion of Russian achievements usually revolves about missiles in their various forms. Even a cursory review at this point would exhaust my time but my last rough count showed more than 30 families of cruise and ballistic missiles of varied capability. Of course, the much discussed SS-9 appears in increasing numbers in the Soviet Union and the news media. This is a formidable weapon and its continued deployment a source of increasing concern to all of us.

A word on Space. The films that we saw were extremely interesting and a subject which the US can understand and definitely be proud of, but Russia went to the moon and back two weeks ago, and did it automatically. This is not meant in any way to discredit the role of the American astronauts, and I think they would be the first to admit, that many of the interventions that they were called upon to perform certainly facilitated the success of the US operation.

A less ominous but most interesting facet of the Soviet technological program is her awakening interest in western markets. I note that the TU-154 transport was designed from the start with western standards in mind. The existence of a flying SST is further testimony to that interest.

All things considered, our chief adversary has achieved excellence in science and technology and we must not ignore or forget that lesson – even for a moment.

2. Air Force Systems for the Seventies

What then is our duty in the R & D business for the Seventies and beyond. I think that I could almost stop at this point and say that Dr Foster focused our attention on that question in a rhetorical but very forceful manner during his earlier remarks. I submit that our work must provide the options for our leaders and thereby, the basis for our security.

Technology for technology's sake, whether we exchange it among ourselves or not is not a task for the Air Force or much less for AGARD. It is a luxury we simply cannot afford.

It has been said by a widely quoted but not necessarily widely admired world figure that "power comes out of the barrel of a gun".

I am convinced our adversaries believe this fact to their core.

This being the case, our efforts and the resulting technology for the Seventies must

– first be convertible into systems

– it must protect us from surprise as much as a ready missile or an alert bomber

– it must be broad enough to allow us to exploit possible useful concepts.

This is a pretty large order for any technology and the importance of filling that order cannot be over emphasized.

Let me illustrate some of our thinking on what we view as hard needs for systems coming into being for the Seventies.

First and foremost, our strategic deterrent rests now on a triad (or troika as it might be called in the Kremlin). This triad is made up of land-based strategic missiles, sea-based strategic missiles, and the manned bomber. We are convinced that each arm of this triad is absolutely essential to the deterrent as are the three legs of a milk stool essential to your stability. We also know that a strategic advantage can be a transient thing. We must continuously upgrade these systems and explore the technology for new systems.

The Minuteman III – equipped with the Mark 12 Multiple Independently-Targeted Re-Entry Vehicle (MIRV) will greatly improve our ballistic missile force and is developing quite well. Our test program has been very successful and these missiles are being deployed in the field today (Fig.1).

Beyond Minuteman III, we are working on the longer lead-time technologies for an even more advanced ballistic missile.

I might add that we are also working on survivability problems facing present and advanced ICBM's, a program which will include the study of hardened silos, mobile Minuteman and close-in hard point defenses.

Another concern is to improve the effectiveness of present and next generation bombers. Here, you see the Short Range Attack Missile (SRAM) being carried on the FB-111. The B-52 fleet will also be equipped with these missiles (Fig.2).

SRAM is a stand-off missile which will give us accurate weapon delivery without exposing our bomber fleets to the enemy's terminal defenses. It is powered by a restartable solid-propellant rocket motor and uses an inertial guidance system. This supersonic missile is presently undergoing development testing at Holloman AFB, New Mexico.

We are firmly convinced that the manned bomber has a role to play in the Seventies, the Eighties and beyond. For flexibility and accuracy such machines are not paralleled at present. We intend to field a totally new manned bomber during the Seventies (Fig.3).

The aircraft will be quite large – in the 350,000 to 400,000 lb class incorporating new aeronautical principles and materials. We plan for it to be able to deliver large payloads, both nuclear and non-nuclear, on long range

targets at subsonic or supersonic speeds. It will have the capability of penetrating sophisticated enemy defenses in either full-scale or limited war action.

In the strategic defense area, we are conducting a technology effort for a modernized air defense system conceptually comprised of an improved interceptor, an Airborne Warning and Control System (AWACS) and a long range, Over-The-Horizon (OTH) radar detection system.

AWACS has the obvious advantage of improved survivability and will provide the primary capability to control present day interceptors as well as an even more advanced interceptor. The AWACS will work in conjunction with the ground-based OTH radar system for detection, and the combination should greatly enhance warning times. The AWACS will also have a tactical application for battle management in any region of the world (Fig.4).

In the airlift area, we are concerned both with inter-theater and intra-theater airlift. This latter involves such tasks as troop transportation, supplying front-line areas, and aeromedical evacuation flights within the combat theater itself.

Our global inter-theater airlift capability is in good shape with the C-141 doing an outstanding job on a daily basis.

The advent of the C-5 has further increased our airlift capabilities (Fig.5).

Thousands of flight testing hours have already been completed and the first C-5's delivered to MAC for crew training. There have been problems during the development of this aircraft - notably with the cost and wing structure. While the first problem is vexing, we believe the second problem is well in hand. Tests to date indicate that the technical performance will meet or exceed operational requirements. The flight crews have been impressed with the ease of flying and the ground handling qualities of the C-5 in spite of its immense size.

For the in-theater logistics support role, our concern is replacing the C-7 and the C-123. This, we hope to do with an off-the-shelf aircraft. Additionally, we are pursuing advanced technology programs in both STOL and V/STOL and I might digress here to say that both of these are areas in which we have cooperated with several of our friends within NATO.

In the tactical area, we are concerned with the need for further improved capabilities in close air support, interdiction, and air superiority. Here, there are real opportunities for significant advances.

We have this summer signed a contract with McDonnell-Douglas for the F-15 air superiority fighter. Here, you see an artist's concept of what the F-15 will look like (Fig.6).

The F-15 will be the best "dogfight" fighter that can be built. The aircraft, expected to be operational in the mid-1970's, will be a single-place, twin-engine jet fighter in the 40,000 pound category. It is anticipated that the F-15 will carry both short- and medium-range missiles as well as internally mounted rapid-firing Gatling gun.

Besides supporting weapons and equipment, the F-15 will have low-wing loading and high thrust-to-weight ratio. These features are being incorporated in the F-15 in order to produce a highly maneuverable aircraft with extremely rapid acceleration and the ability to perform tight turns at high speeds. We expect it to be a match for anything that the Soviets can build in the foreseeable future.

We are also proposing an A-X for the close-air support role. We have asked the aviation industry to submit design proposals. We intend for the A-X to be rugged, and built for sustained operations under the austere conditions of semi-prepared airstrips. A major feature will be survivability in the battle area. Its design will incorporate whatever new close air support weapon delivery technology is available (Fig.7).

We are concentrating heavily on "survivability technology" for the A-X as well as heavy payload and long endurance.

Finally, we have the Gunship II program. As you know, the old AC-47 which started out as Puffs Romantic Dragon has done a magnificent job in SEA, and has proven the feasibility of the side-firing gunship concept. On the basis of this success, C-130's and C-119's have been converted to gunships by adding improved armaments such as miniguns, 20 mm and 40 mm cannons and a wide range of detection and sensing equipment and even designator equipment (Fig.8).

In space-based communications we have the satellite portion of the Defense Satellite Communication System (DSCS). This is a point-to-point repeater satellite system with 24 of the originally launched 26 small, relatively simple satellites operating in equatorial orbit. These satellites are used operationally with great effectiveness not only for conventional communications, but also for transmission of high quality intelligence photographs from Vietnam to the Pentagon. The second phase of the program will place advanced satellites with a far greater communications capacity in geo-stationary orbit starting early in 1971. The actual role of the Air Force is to develop and orbit the satellites as part of the communication system for the Defense Communications Agency (Fig.9).

We have also developed the satellites for the Tactical Satellite Communications System, TACSATCOM. This program has proven the concept of communications by satellite between mobile users such as aircraft, ships, jeeps, and even troops with manpack radios. The TACSAT I satellite and terminal assets were turned over to the Joint Chiefs of Staff for operational use on the first of July. Terminals are being installed in the world-wide airborne command post fleet (Fig.10).

3. R & D Approaches for the Seventies

With that very rapid overview of some of the systems, which will be with us during the Seventies and the knowledge that they rest on technologies developed in the Sixties, let me now share with you some views on technology and concepts which we think show promise for the Seventies. I yield that much of what I will say is not news to you, but hopefully will provide some insight on a few of the more promising efforts.

First, the composite materials, a subject, I am sure, of much interest to your Structures and Materials Panel. We view the promise of these materials as pervading almost all facets of aerodynamic structures.

The advantages of such materials are legion and we see weight reductions of 25-50% if aircraft or major portions of them can be built with them.

As you might expect we are taking a measured approach from simple empenage structure to more complex assemblies. A portion of the F-111 made in large part from graphite is designed to replace metallic components in our current operational F-111 and will ultimately be test flown. It has withstood 127% of design ultimate load before failure and it weighs far less than its metallic counterpart. Much remains to be done and we seriously intend to pursue the technology.

We also see great promise in an old trick with new twists and that is the "fly-by-wire" or advanced control concepts. When one considers the more than 140 joints and linkages between the stick and the control surfaces on the F-111, the concept is *very* appealing.

With the development of a highly reliable all-electrical fly-by-wire control system for aircraft, designers will soon be able to completely mission-optimize an aircraft without regard to conventional stability and control constraints. Full time electrical control systems will function to provide the aircraft with idealized flying characteristics while the conventional nonstable designs will allow increased maneuverability and a 15-25% reduction in gross take-off weights to accomplish the same mission.

Another area which we will be exploring in the Seventies will have, in our view, a measurable impact on aircraft design.

Please note the landing gear, of the C-5 (see Figure 5).

Here you see 35,000 lbs of complicated expensive structure. It amounts to 13% of the structural weight of the C-5.

In Figure 11 you see a small plane equipped with an air cushion landing system taking off from a stream. It has also done so in mud, stubble, snow, swamp and a variety of other surfaces. The first questions that come to mind as you view the little craft is how do you stop it, steer it and park it. It can be done and we are proceeding to scaled-up systems in the near future.

As you well know, research and development programs to provide advanced engine technology for future aircraft are high priority subjects with us.

We must push this technology hard, we cannot live through the Seventies merely by up-grading existing engines. We must strive for power plants which provide thrust-to-weight ratios of 15:1, this, of course, means turbine inlet temperatures as high as 3500°F.

Besides further increasing the turbine engine technology base that we have today, we will be developing the technology that will give us dual cycle engines which are a combination of two or more different propulsion cycles in a single engine frame for advanced aircraft missions.

The technology areas of high Mach acceleration, high specific thrust, ramjet cruise and use of advanced JP fuels will provide engines with high thrust-to-weight, maximum performance for rapid acceleration and high speed cruise (Mach number 4.0 to 5.0).

I would certainly be remiss if I did not touch lightly for a moment, and I do mean touch only lightly, on the almost unbelievable wealth of possibilities coming from our people who work in electronics. Probably the greatest single advance for attack airplanes will be the phased array radar antennas. It will permit a single multi mode radar to operate simultaneously in almost all of its operational roles with the high reliability of multiple transmitter and receiving elements. We intend to push forward here.

In a related sense the laser has a strong role to play in avionics. I might mention here that in the Congress this year the Secretary singled out the laser as being one of the three significant developments of mankind in recent times. He didn't convince the local Congressman who turned to me and asked what was my view as regards the more important significance of that development along with transistors and nuclear energy as contrasted with the rubber tire tractor and hybrid corn. It shows you that there are different points of view on some of our technical breakthroughs. Nevertheless, the laser and its uses are almost limitless and we have been slowly working our way into a number of these. As you know, the uses of such devices are manifold – illumination of targets at night, accurate ranging, and such simple things as the bore-sighting of guns. All of these have been made possible or simplified by the use of various types of lasers and I anticipate in the 70's we shall see a great many more applications for the variety of lasers that are coming on the market today. The ability to see through fog and smoke is, of course, of great value. Such devices operating at about 3 mm wavelengths could act as search lights with a receiver sensing the reflections and a converter providing a display to the aircrew.

We look forward to self-contained electro-optical systems which can provide a ground scene similar to a household TV set. Special detectors which amplify the light received allow the system to produce a visible scene under only starlight. We see systems capable of scanning variable azimuth and elevation and from wide to narrow fields of view.

The tremendous advances in sensor technology and the resulting wealth of information available inevitably leads to the increasing use of digital computers for data handling and selection of information to be displayed to the aircrew. The possibilities of such devices to perform a variety of functions for the aircraft and crew are limitless. In my own view, one of the big problems we must be careful of is the tendency of most engineers to use every capability available thereby completely overloading the poor human who must ultimately react to the information.

Nevertheless, the computer will see increasing use in combat airplanes. One interesting use which we are pressing forward with is the helmet mounted gunsight. The concept is simple – you look at the target and the computer points the weapon. Taken to their ultimate development such devices may have a profound effect on the types and designs of future aircraft. Other uses we can envision are automatic monitoring of system performance, integral maintenance surveillance, and a host of other functions.

I could continue, the vista in our business is limitless. I have been brief, and necessarily so. Let me then leave you with the final thought that I for one do not view the world we live in as a place safe for our free forms of Government. The maintenance of the power base that allows us to exist rests directly on our ability to remain technologically alert and strong. That was our business during the Sixties and we are here today, due in large part, to the fact that we were successful. The Seventies are full of problems and promise. We must succeed.

Thank you.

Fig.1 Minuteman III

Fig.2 The FB-111/SRAM

Fig.3 New manned bomber

Fig.4 AWACS

Fig.5 C-5

Fig.6 F-15

Fig.7 A-X

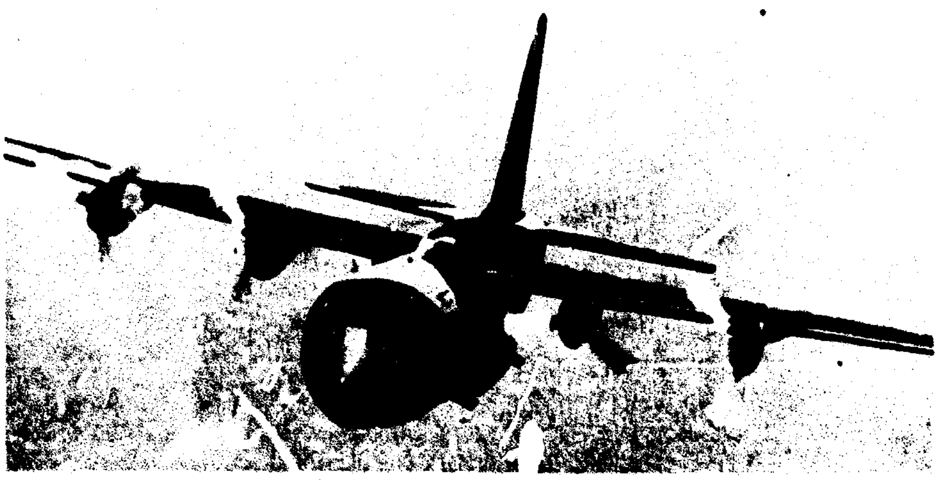

Fig.8 C-130 Gunship

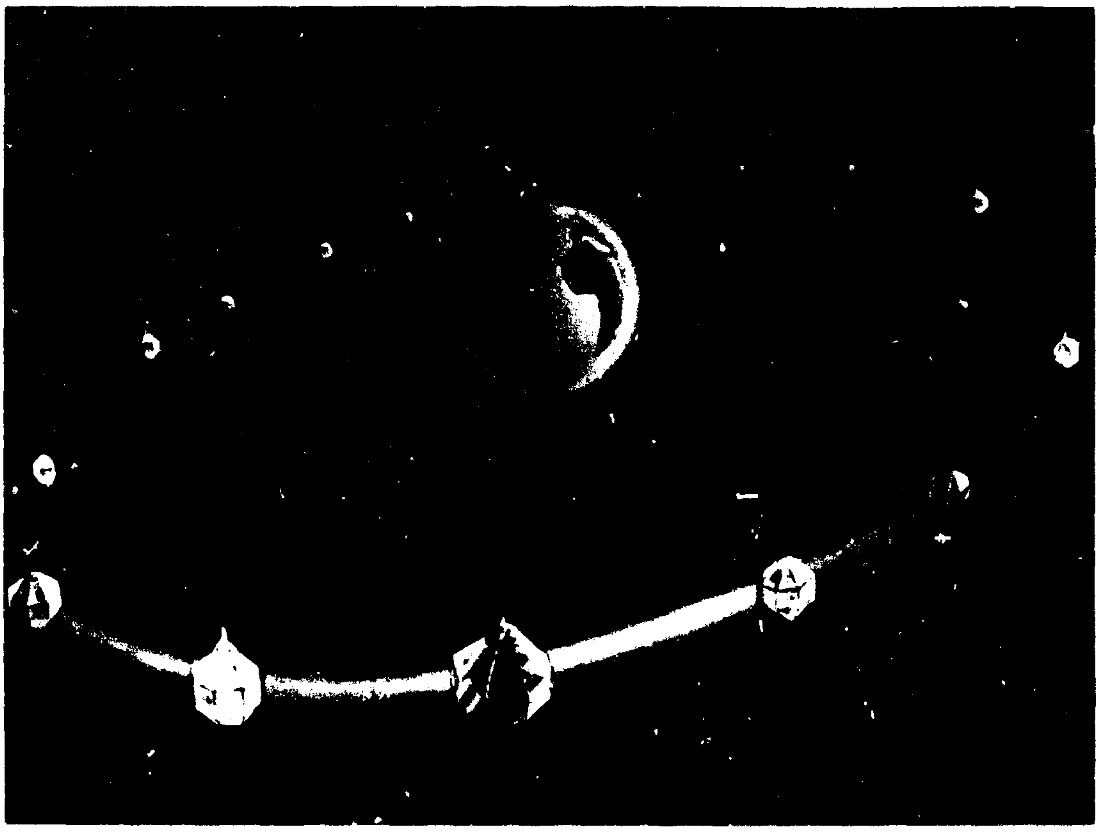

Fig.9 Initial defense satellite communication system

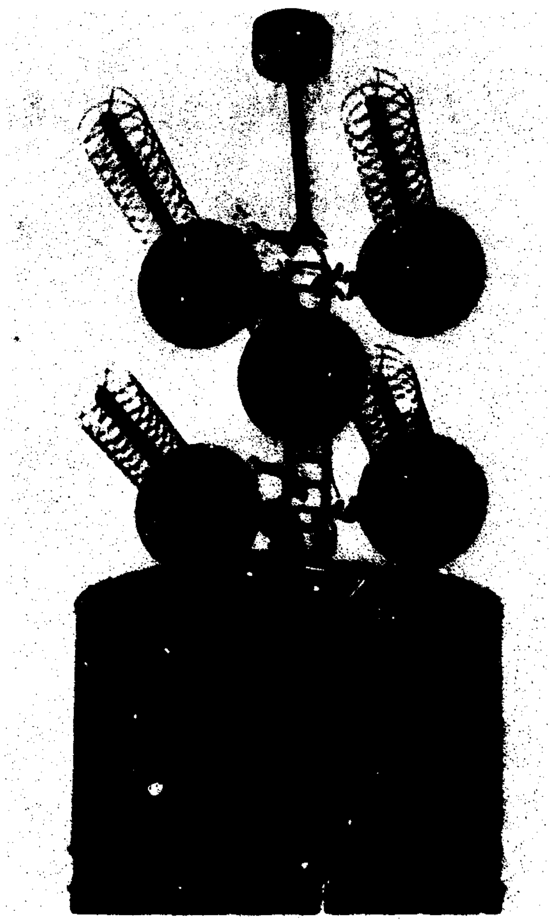

Fig.10 TACSAT 1

Fig.11 Air cushion landing system

Mr Hansen thanked General Glasser for his speech:

Thank you very much, General Glasser for an excellent insight into our future technology base and weapon systems.

And now, Chairman Benecke may I turn the floor back to you.

Closing Remarks by Dr Benecke

Secretary Hansen On behalf of all of us here this afternoon, I wish to extend our sincere gratitude to you and each of the distinguished speakers.

Dr Foster, General Glasser, Mr Armstrong and Mr Ames I know that we all have a much better appreciation and understanding of the aerospace research and development underway in the United States. It is a most impressive program and one that all of us in the Alliance appreciate being associated with.

I would like to now close the Sixth AGARD Annual Meeting.